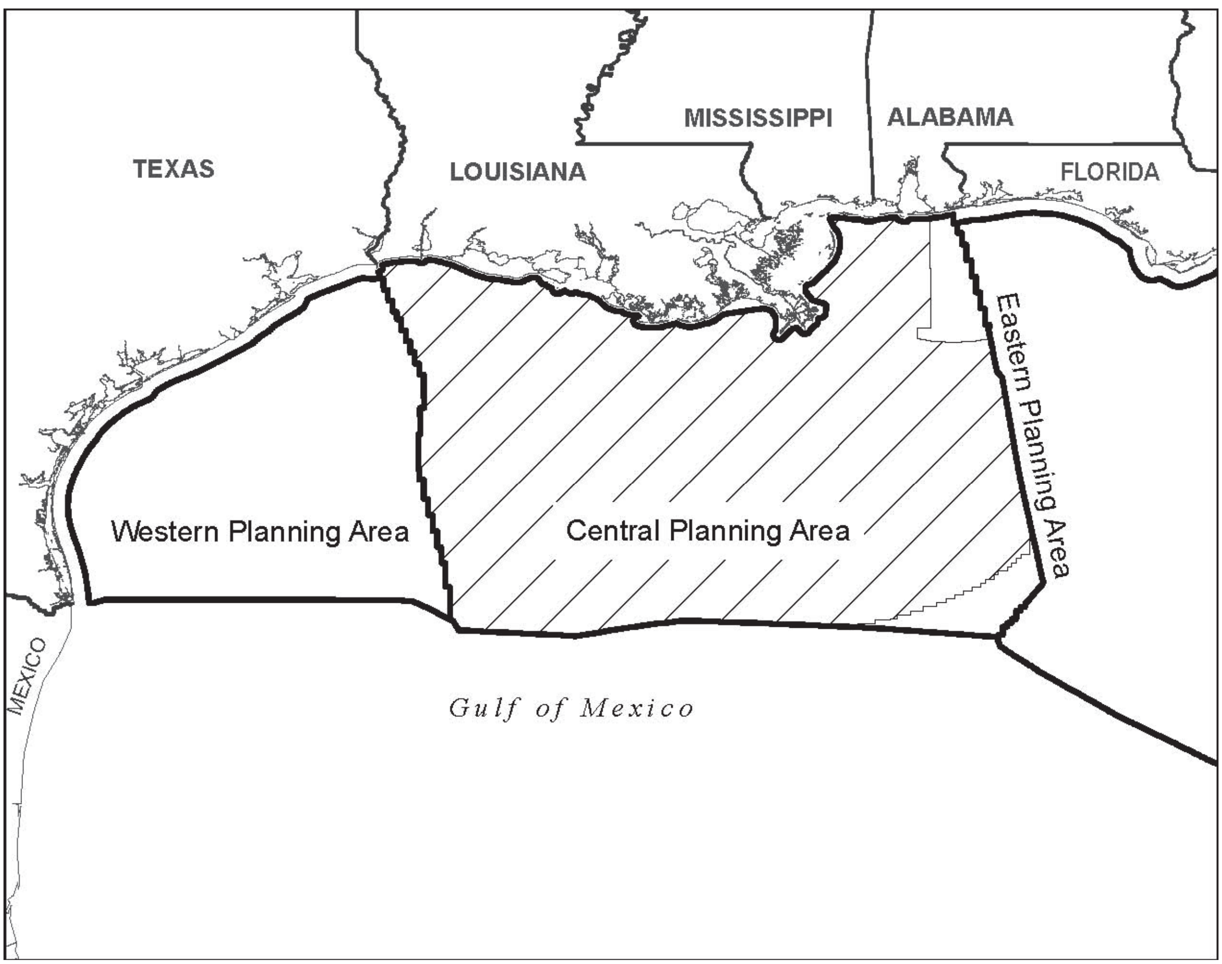
OCS EIS/EA
BOEMRE 2011-027

Gulf of Mexico OCS
Oil and Gas Lease Sale: 2012

Central Planning Area Lease Sale 216/222

Draft Supplemental Environmental Impact Statement



U.S. Department of the Interior
Bureau of Ocean Energy Management,
Regulation and Enforcement
Gulf of Mexico OCS Region

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REGIONAL DIRECTOR'S NOTE

In the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012*, six annual areawide lease sales are scheduled for the Central Planning Area (CPA) and five annual areawide lease sales are scheduled for the Western Planning Area (WPA). Federal regulations allow for several related or similar proposals to be analyzed in one environmental impact statement (EIS) (40 CFR 1502.4). Since each lease sale proposal and projected activities are very similar each year for each sale area, this Agency prepared a single EIS for the 11 lease sales: *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Final Environmental Impact Statement*. The Gulf of Mexico Energy Security Act of 2006 (P.L. 109-432, December 20, 2006) repealed the Congressional moratorium on certain areas of the Gulf of Mexico, placed a moratorium on other areas in the Gulf of Mexico, and increased the distribution of offshore oil and gas revenues to coastal States. The remaining eight CPA and WPA sales were analyzed in the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement.*

This Draft Supplemental EIS was prepared because of the potential changes to the baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of (1) the *Deepwater Horizon* (DWH) event between April 20 and July 15, 2010 (the period when oil flowed from the Macondo well in Mississippi Canyon Block 252); (2) the acute impacts that have been reported or surveyed since that time; and (3) any new information that may be available. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Draft Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments. It is important to note that this Draft Supplemental EIS was prepared using the best information that was publicly available at the time the document was prepared.

At the completion of this Supplemental EIS process, a decision will be made only for proposed consolidated Lease Sale 216/222 in the Central Planning Area.

The Gulf of Mexico OCS Region of the Bureau of Ocean Energy Management, Regulation and Enforcement has been conducting environmental analyses of the effects of Outer Continental Shelf (OCS) oil and gas development since the inception of the National Environmental Policy Act of 1969. We have prepared and published more than 50 draft and final EIS's. Our goal has always been to provide factual, reliable, and clear analytical statements in order to inform decisionmakers and the public about the environmental effects of proposed OCS activities and their alternatives. We view the EIS process as providing a balanced forum for early identification, avoidance, and resolution of potential conflicts. It is in this spirit that we welcome comments on this document from all concerned parties.

Lars Herbst

Lars Herbst
Regional Director
Bureau of Ocean Energy Management,
Regulation and Enforcement
Gulf of Mexico OCS Region

COVER SHEET

Supplemental Environmental Impact Statement
for
Proposed Central Planning Area OCS Oil and Gas Lease Sale 216/222

	Draft (x)	Final ( )
Type of Action:	Administrative (x)	Legislative ( )

Area of Potential Impact: Offshore Marine Environment and Coastal Counties/Parishes of Louisiana, Mississippi, and Alabama

Agency	Washington Contact	Region Contacts
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ABSTRACT

This Supplemental Environmental Impact Statement (EIS) covers the proposed Gulf of Mexico OCS oil and gas consolidated Lease Sale 216/222 in the Central Planning Area.

This Supplemental EIS tiers from the following EIS's: the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement* (5-Year Program EIS; USDOI, MMS, 2007a), which defined the national program; the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Final Environmental Impact Statement* (Multisale EIS; USDOI, MMS, 2007b), which defined the 5-Year Program in the GOM; and the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement* (2009-2012 Supplemental EIS; USDOI, MMS, 2008), which was required after passage of the Gulf of Mexico Energy Security Act of 2006.

This Supplemental EIS was prepared because of the potential changes to baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of (1) the *Deepwater Horizon* event between April 20 and July 15, 2010 (the period when oil flowed from the Macondo well in Mississippi Canyon Block 252); (2) the acute impacts that have been reported or surveyed since that time; and (3) any new information that may be available. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments.

The proposed action is a major Federal action requiring an EIS. This document provides the following information in accordance with the National Environmental Policy Act and its implementing regulations, and it will be used in making decisions on the proposal. This document includes the purpose and background of the proposed action, identification of the alternatives, description of the affected environment, and an analysis of the potential environmental impacts of the proposed action, alternatives, and associated activities, including proposed mitigating measures and their potential effects. Potential contributions to cumulative impacts resulting from activities associated with the proposed action are also analyzed.

Hypothetical scenarios were developed on the levels of activities, accidental events (such as oil spills), and potential impacts that might result if the proposed action is adopted. Activities and disturbances associated with the proposed action on biological, physical, and socioeconomic resources are considered in the analyses.

Additional copies of this Supplemental EIS, the Multisale EIS, the 2009-2012 Supplemental EIS, and the other referenced publications may be obtained from the BOEMRE, Gulf of Mexico OCS Region, Public Information Office (MS 5034), 1201 Elmwood Park Boulevard, New Orleans, Louisiana 70123-2394, or by telephone at 504-736-2519 or 1-800-200-GULF.

SUMMARY

Under the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012* (5-Year Program; USDOI, MMS, 2007a), six annual areawide lease sales were scheduled for the Central Planning Area (CPA) and five annual areawide lease sales are scheduled for the Western Planning Area (WPA) of the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). Those 11 CPA and WPA sales were analyzed in the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Final Environmental Impact Statement* (Multisale EIS; USDOI, MMS, 2007b) and are hereby incorporated by reference.

The Gulf of Mexico Energy Security Act (GOMESA) of 2006 (P.L. 109-432, December 20, 2006) repealed the Congressional moratorium on certain areas of the Gulf of Mexico, placed a moratorium on other areas in the Gulf of Mexico, and increased the distribution of offshore oil and gas revenues to coastal States. The remaining seven CPA and WPA sales were analyzed in the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement* (2009-2012 Supplemental EIS; USDOI, MMS, 2008a) and are hereby incorporated by reference.

This Supplemental environmental impact statement (EIS) supplements the Multisale EIS and the 2009-2012 Supplemental EIS. This Supplemental EIS analyzes the potential environmental effects of oil and natural gas leasing, exploration, development, the effects of the *Deepwater Horizon* (DWH) event, and all new information available for the CPA since the publication of the Multisale EIS and the 2009-2012 Supplemental EIS.

The purpose of this Supplemental EIS is to determine if new information is substantial enough to alter conclusions stated in the Multisale EIS and the 2009-2012 Supplemental EIS and, if so, to disclose those changes. This includes all new information and not just that acquired since the DWH event. It must be understood that this Supplemental EIS analyzes the proposed action and alternatives for a CPA proposed lease sale. This is not an EIS on the DWH event, although information on this event will be analyzed as it applies to resources in the CPA. Proposed consolidated CPA Lease Sale 216/222 is the Federal action addressed in this Supplemental EIS and is the remaining areawide oil and gas lease sale in the CPA.

In the National Environmental Policy Act's (NEPA) implementing regulations (40 CFR 1508.28), "tiering" refers to the coverage of general matters in a broader EIS (such as national program), with subsequent narrower statements of environmental analyses (such as regional action). Tiering is appropriate in this instance because broader program issues have already been subjected to analysis and because this Supplemental EIS is more narrowly focused on the site-specific statement or analysis for proposed CPA Lease Sale 216/222. This Supplemental EIS tiers from the following EIS's: the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement* (5-Year Program EIS; USDOI, MMS, 2007c), which defined the national program; the Multisale EIS, which defined the 5-Year Program in the GOM; and the 2009-2012 Supplemental EIS, which was required after the passage of GOMESA.

This summary section is only a brief overview of the proposed lease sale, alternatives, significant issues, potential environmental and socioeconomic effects, and proposed mitigating measures contained in this Supplemental EIS. To obtain the full perspective and context of the potential environmental and socioeconomic impacts discussed, it is necessary to read the entire analyses. Relevant discussions can be found in the chapters of this Supplemental EIS as described below.

- **Chapter 1**, The Proposed Action, describes the purpose of and need for the proposed lease sale and describes the prelease process.
- **Chapter 2**, Alternatives Including the Proposed Action, describes the environmental and socioeconomic effects of the proposed lease sale and alternatives. Also discussed are potential mitigating measures to avoid or minimize impacts.
- **Chapter 3**, Impact-Producing Factors and Scenario, describes activities associated with the proposed lease sale and the OCS Program, and other foreseeable activities that could potentially affect the biological, physical, and socioeconomic resources of the Gulf of Mexico.

Chapter 3.1, Impact-Producing Factors and Scenario—Routine Events, describes offshore infrastructure and activities (impact-producing factors) associated with the proposed lease sale that could potentially affect the biological, physical, and socioeconomic resources of the Gulf of Mexico.

Chapter 3.2, Impact-Producing Factors and Scenario—Accidental Events, discusses potential accidental events (i.e., oil spills, losses of well control, vessel collisions, and spills of chemicals or drilling fluids) that may occur as a result of activities associated with the proposed lease sale.

Chapter 3.3, Cumulative Activities Scenario, describes past, present, and reasonably foreseeable future human activities, including non-OCS activities, as well as all OCS activities, that may affect the biological, physical, and socioeconomic resources of the Gulf of Mexico.

- **Chapter 4**, Description of the Environment and Impact Analysis, describes the affected environment and provides analysis of the routine, accidental, and cumulative impacts of the CPA proposed action and the alternatives on environmental and socioeconomic resources of the Gulf of Mexico.

Chapter 4.1, Alternatives Including the Proposed Action, describes the impacts of the proposed action and three alternatives to the CPA proposed action on the biological, physical, and socioeconomic resources of the Gulf of Mexico.

Chapter 4 also includes **Chapter 4.2**, Unavoidable Adverse Impacts of the Proposed Action; **Chapter 4.3**, Irreversible and Irretrievable Commitment of Resources; and **Chapter 4.4**, Relationship Between the Short-term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity.

- **Chapter 5**, Consultation and Coordination, describes the consultation and coordination activities with Federal, State, and local agencies and other interested parties that occurred during the development of this Supplemental EIS.
- **Chapter 6**, References Cited, is a list of literature cited throughout this Supplemental EIS.
- **Chapter 7**, Preparers, is a list of names of persons who were primarily responsible for preparing and reviewing this Supplemental EIS.
- **Chapter 8**, Glossary, is a list of specialized words with brief definitions used in this document.

Proposed Action and Alternatives

The following alternatives were included for analysis in the Multisale EIS. No new alternatives were proposed for proposed CPA Lease Sale 216/222.

Alternatives for Proposed Central Planning Area Lease Sale 216/222

Alternative A—The Proposed Action: This alternative would offer for lease all unleased blocks within the CPA for oil and gas operations (**Figure 2-1**), except for the following:

(1) blocks directly south of Florida and within 100 miles (mi) (161 kilometers [km])of the Florida coast (north of the easternmost portion of the proposed CPA lease sale area as shown on **Figure 1-1**); and

(2) blocks that are beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap.

The CPA sale area encompasses about 63 million acres (ac) of the CPA's 66.3 million ac. Approximately 37.1 million ac (59%) of the CPA sale area is currently unleased. The estimated amount of natural resources projected to be developed as a result of the proposed CPA lease sale is 0.801-1.624 billion barrels of oil (BBO) and 3.332-6.560 trillion cubic feet (Tcf) of gas.

Alternative B—The Proposed Action Excluding the Unleased Blocks Near Biologically Sensitive Topographic Features: This alternative would offer for lease all unleased blocks in the CPA, as described for the proposed action (Alternative A), with the exception of any unleased blocks subject to the Topographic Features Stipulation.

Alternative C—The Proposed Action Excluding the Unleased Blocks within 15 Miles of the Baldwin County, Alabama, Coast: This alternative would offer for lease all unleased blocks in the CPA, as described for the proposed action (Alternative A), with the exception of any unleased blocks within 15 mi (24 km) of the Baldwin County, Alabama, coast.

Alternative D—No Action: This alternative is the cancellation of the proposed CPA lease sale. The opportunity for development of the estimated 0.801-1.624 BBO and 3.332-6.560 Tcf of gas that could have resulted from the proposed CPA lease sale would be precluded or postponed. Any potential environmental impacts resulting from the proposed lease sale would not occur or would be postponed. This is also analyzed in the EIS for the 5-Year Program on a nationwide programmatic level.

Mitigating Measures

The proposed action includes existing regulations and proposed lease stipulations designed to reduce environmental risks, potential multiple-use conflicts between OCS operations and U.S. Department of Defense activities. Eight lease stipulations are proposed for the proposed CPA lease sale—the Topographic Features Stipulation, the Live Bottom Stipulation, the Military Areas Stipulation, the Evacuation Stipulation, the Coordination Stipulation, the Blocks South of Baldwin County, Alabama, Stipulation, the Protected Species Stipulation, and the Law of the Sea Convention Royalty Payment Stipulation

Application of lease stipulations will be considered by the Assistant Secretary of the Interior for Land and Minerals (ASLM). The analysis of the stipulations as part of the proposed action does not ensure that the ASLM will make a decision to apply the stipulations to leases that may result from the proposed lease sale, nor does it preclude minor modifications in wording during subsequent steps in the prelease process if comments indicate changes are necessary or if conditions warrant. Any stipulations or mitigation requirements to be included in the lease sale will be described in the Final Notice of Sale. Mitigation measures in the form of lease stipulations are added to the lease terms and are therefore enforceable as part of the lease.

Scenarios Analyzed

Offshore activities are described in the context of scenarios for the proposed action (**Chapter 3.1**) and for the OCS Program (**Chapter 3.3**). The Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEMRE's) Gulf of Mexico OCS Region developed these scenarios to provide a framework for detailed analyses of potential impacts of the proposed lease sale. The scenarios are presented as ranges of the amounts of undiscovered, unleased hydrocarbon resources estimated to be leased and discovered as a result of the proposed action. The analyses are based on an assumed range of activities (e.g., the installation of platforms, wells, and pipelines, and the number of helicopter operations and service-vessel trips) that would be needed to develop and produce the amount of resources estimated to be leased.

The cumulative analysis (**Chapter 4.1**) considers environmental and socioeconomic impacts that may result from the incremental impact of the lease sale when added to all past, present, and reasonably foreseeable future human activities, including non-OCS activities such as import tankering and commercial fishing, as well as all OCS activities (OCS Program). The OCS Program scenario includes all activities that are projected to occur from past, proposed, and future lease sales during the 40-year analysis period. This includes projected activity from lease sales that have been held, but for which exploration or development has not yet begun or is continuing. In addition to human activities, impacts from natural occurrences, such as hurricanes, are analyzed.

Significant Issues

The major issues that frame the environmental analyses in this Supplemental EIS are the result of concerns raised during years of scoping for the Gulf of Mexico OCS Program. Issues related to OCS exploration, development, production, and transportation activities include oil spills, wetlands loss, air emissions, discharges, water quality degradation, trash and debris, structure and pipeline emplacement activities, platform removal, vessel and helicopter traffic, multiple-use conflicts, support services, population fluctuations, demands on public services, land-use planning, tourism, aesthetic interference, cultural impacts, environmental justice, and consistency with State coastal zone management programs. Environmental resources and activities identified during the scoping process to warrant an environmental analysis include air quality, water quality, coastal barrier beaches and associated dunes, wetlands, seagrass communities, live bottoms (Pinnacle Trend and low relief), topographic features, *Sargassum*, deepwater benthic communities, marine mammals, sea turtles, beach mice, coastal and marine birds, Gulf sturgeon, fish resources and essential fish habitat, commercial and recreational fishing, recreational resources, archaeological resources, socioeconomic conditions, soft bottoms, and diamondback terrapins.

Other issues include impacts from the DWH event and from past and future hurricanes on environmental and socioeconomic resources, and on coastal and offshore infrastructure. During the past few years, the Gulf Coast States and Gulf of Mexico oil and gas activities have been impacted by major hurricanes. Appendix A.3 of the Multisale EIS provides detailed information on Hurricanes Lili (2002), Ivan (2004), Katrina (2005), and Rita (2005), which are discussed in **Chapter 4**. The description of the affected environment (**Chapter 4.1**) includes impacts from these storms, as well as Hurricanes Gustav (2008) and Ike (2008), on the physical environment, biological environment, and socioeconomic activities and OCS-related infrastructure. Baseline data are considered in the assessment of impacts from the proposed action to the resources and the environment (**Chapter 4.1)**.

Impact Conclusions

The BOEMRE has reexamined the analysis presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information available since the publication of the Multisale EIS and the 2009-2012 Supplemental, and the DWH event. No substantial new information, with the exception of archaeological resources, was found that would alter the impact conclusions as presented in the Multisale EIS and the 2009-2012 Supplemental EIS for a CPA lease sale. In some cases, new information that supported these conclusions was found.

The full analyses of the potential impacts of routine activities and accidental events associated with the proposed action and the proposed action's incremental contribution to the cumulative impacts are described in **Chapter 4.1**. A summary of the potential impacts from the CPA proposed action on each environmental and socioeconomic resource and the conclusions of the analyses can be found below.

Air Quality: Emissions of pollutants into the atmosphere from the routine activities associated with the CPA proposed action are projected to have minimal impacts to onshore air quality because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from the coastline, and are expected to be well within the National Ambient Air Quality Standards (NAAQS). While regulations are in place to reduce the risk of impacts from H_2S and while no H_2S-related deaths have occurred on the OCS, accidents involving high concentrations of hydrogen sulfide (H_2S) could result in deaths as well as environmental damage. These emissions from routine activities and accidental events associated with the proposed action are not expected to have concentrations that would change onshore air quality classifications.

Coastal and Offshore Waters: Impacts from routine activities associated with the CPA proposed action would be minimal if all existing regulatory requirements are met. Coastal water impacts associated with routine activities include increases in turbidity resulting from pipeline installation and navigation canal maintenance, discharges of bilge and ballast water from support vessels, and run-off from shore-based facilities. Offshore water impacts associated with routine activities result from the discharge of drilling muds and cuttings, produced water, residual chemicals used during workovers, structure installation and removal and pipeline placement. The discharge of drilling muds and cuttings cause temporary increased turbidity and changes in sediment composition. The discharge of produced water results in increased concentrations of some metals, hydrocarbons, and dissolved solids within an area of about 100 meters (m) (328 feet [ft]) adjacent to the point of discharge. Structure installation and removal and pipeline placement disturbs the sediments and causes increased turbidity. In addition, offshore water impacts result from supply and service-vessel bilge and ballast water discharges.

Small spills (<1,000 bbl) are not expected to significantly impact water quality in coastal or offshore waters. Large spills (≥1,000 bbl), however, could impact water quality in coastal waters. Accidental chemical spills, release of synthetic-based fluid (SBF), and blowouts would have temporary localized impacts on water quality.

Coastal Barrier Beaches and Associated Dunes: Routine activities in the CPA such as increased vessel traffic, maintenance dredging of navigation canals, and pipeline installation would cause negligible impacts and would not deleteriously affect barrier beaches and associated dunes. Indirect impacts from routine activities are negligible and indistinguishable from direct impacts of onshore activities. The potential impacts from accidental events, primarily oil spills, associated with the CPA proposed action are anticipated to be minimal.

Wetlands: Routine activities in the CPA such as pipeline emplacement, navigational channel use, maintenance dredging, disposal of OCS wastes, and construction and maintenance of OCS support infrastructure in coastal areas are expected to result in low impacts. Indirect impacts from wake erosion and saltwater intrusion are expected to result in low impacts that are indistinguishable from direct impacts from inshore activities. The potential impacts from accidental events, primarily oil spills, are anticipated to be minimal.

Seagrass Communities: Turbidity impacts from pipeline installation and maintenance dredging associated with the proposed action would be temporary and localized. The increment of impacts from service-vessel transit associated with the proposed action would be minimal. Should an oil spill occur near a seagrass community, impacts from the spill and cleanup would be considered short term in duration and minor in scope. Close monitoring and restrictions on the use of bottom-disturbing equipment to clean up the spill would be needed to avoid or minimize those impacts.

Live Bottoms (Pinnacle Trend and Low Relief): The combination of its depth (200-400 ft; 60-120 m), separation from sources of impacts as mandated by the Live Bottoms (Pinnacle Trend and Low Relief) Stipulation, and a community adapted to sedimentation makes damage to the ecosystem unlikely from routine activities associated with a CPA proposed action. In the unlikely event that oil from a subsurface spill would reach the biota of these communities, the effects would be primarily sublethal for adult sessile biota and there would be limited incidences of mortality.

Topographic Features: The routine activities associated with the CPA proposed action that would impact topographic feature communities include anchoring, infrastructure and pipeline emplacement, infrastructure removal, drilling discharges, and produced-water discharges. However, adherence to the proposed Topographic Features Stipulation would make damage to the ecosystem unlikely. Contact with accidentally spilled oil would cause lethal and sublethal effects in benthic organisms, but the oiling of benthic organisms is not likely because of the small area of the banks, the scattered occurrence of spills, the depth of the features, and because the proposed Topographic Features Stipulation would keep subsurface sources of spills away from the immediate vicinity of topographic features.

Sargassum: The impacts to *Sargassum* that are associated with the proposed action are expected to have only minor effects to a small portion of the *Sargassum* community as a whole. The *Sargassum* community lives in pelagic waters with generally high water quality and would be resilient to the minor effects predicted. It has a yearly cycle that promotes quick recovery from impacts. No measurable impacts are expected to the overall population of the *Sargassum* community from the CPA proposed action.

Chemosynthetic and Nonchemosynthetic Deepwater Benthic Communities: Chemosynthetic and nonchemosynthetic communities are susceptible to physical impacts from structure placement, anchoring, and pipeline installation associated with the CPA proposed action; however, the provisions of Notice to Lessees and Operators (NTL) 2009-G40 greatly reduce the risk of these physical impacts by requiring avoidance of potential chemosynthetic communities and by consequence avoidance of other hard-bottom communities. Even in situations where substantial burial of typical benthic infaunal communities occurred, recolonization from populations from widespread, neighboring, soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms. Potential accidental events associated with the proposed action are expected to cause little damage to the ecological function or biological productivity of the widespread, low-density chemosynthetic communities and the widespread, typical, deep-sea benthic communities.

Marine Mammals: Routine events related to the CPA proposed action, particularly when mitigated as required by BOEMRE, are not expected to have long-term adverse effects on the size and productivity of any marine mammal species or population endemic to the northern Gulf of Mexico. Characteristics of impacts from accidental events depend on chronic or acute exposure resulting in harassment, harm, or mortality to marine mammals, while exposure to dispersed hydrocarbons is likely to result in sublethal impacts.

Sea Turtles: The routine activities of the CPA proposed action are unlikely to have significant adverse effects on the size and recovery of any sea turtle species or population in the Gulf of Mexico. Accidental events associated with the proposed action have the potential to impact small to large numbers of sea turtles. Populations of sea turtles in the northern Gulf of Mexico would be exposed to residuals of oils spilled as a result of the proposed action during their lifetimes. While chronic or acute exposure from accidental events may result in the harassment, harm, or mortality to sea turtles, in most foreseeable cases, exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick would result in sublethal impacts.

Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice: An impact from the consumption of beach trash and debris associated with a CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but unlikely. While potential spills that could result from a CPA proposed action are not expected to contact beach mice or their habitats, large-scale oiling of beach mice could result in extinction, and if not properly regulated, oil-spill response and cleanup activities could have a significant impact to the beach mice and their habitat.

Coastal and Marine Birds: The majority of effects resulting from routine activities associated with the CPA proposed action on endangered/threatened and nonendangered/nonthreatened coastal and marine birds are expected to be sublethal. These effects include behavioral effects, exposure to or intake of OCS-related contaminants or discarded debris, temporary disturbances, and displacement of localized groups from impacted habitats. Impacts from potential oil spills associated with the proposed action and oil-spill cleanup on birds are expected to be negligible; however, small amounts of oil can affect birds, and there are possible delayed impacts on their food supply.

Gulf Sturgeon: Routine activities in the CPA such as installation of pipelines, maintenance dredging, potential vessel strikes, and nonpoint-source runoff from onshore facilities would cause negligible impacts and would not deleteriously affect Gulf sturgeon. Indirect impacts from routine activities to inshore habitats are negligible and indistinguishable from direct impacts of inshore activities. The potential impacts from accidental events, mainly oil spills associated with a CPA proposed action, are anticipated to be minimal. Because of the floating nature of oil and the small tidal range of the Gulf of Mexico, oil spills alone would typically have very little impact on benthic feeders such as the Gulf sturgeon.

Fish Resources and Essential Fish Habitat: Fish resources and essential fish habitat could be impacted by coastal environmental degradation, marine environmental degradation, pipeline trenching, and offshore discharges of drilling discharges and produced waters associated with routine activities. The impact of coastal and marine environmental degradation is expected to cause an undetectable decrease in fish resources or in essential fish habitat. Impacts of routine discharges are localized in time and space and are regulated by U.S. Environmental Protection Agency permits and would have minimal impact. Accidental events that could impact fish resources and essential fish habitat include blowouts and oil or chemical spills. A subsurface blowout would have a negligible effect on Gulf of Mexico fish resources. If spills due to the proposed action were to occur in open waters of the OCS proximate to mobile adult

finfish or shellfish, the effects would likely be nonfatal, and the extent of damage would be reduced due to the capability of adult fish and some adult shellfish to avoid a spill.

Commercial Fishing: Routine activities in the CPA, such as seismic surveys and pipeline trenching, would cause negligible impacts and would not deleteriously affect commercial fishing activities. Indirect impacts from routine activities to inshore habitats are negligible and indistinguishable from direct impacts of inshore activities on commercial fisheries. The potential impacts from accidental events, a well blowout or an oil spill, associated with the CPA proposed action are anticipated to be minimal. Commercial fishermen are anticipated to avoid the area of a well blowout or an oil spill. Any impact on catch or value of catch would be insignificant compared with natural variability.

Recreational Fishing: Routine activities in the CPA, such as seismic surveys and pipeline trenching, would cause negligible impacts and would not deleteriously affect recreational fishing activities. Indirect impacts to inshore habitats are negligible and indistinguishable from direct impacts of inshore activities on recreational fisheries. Temporary localized impacts to recreational fishermen from oil spills are anticipated as a result of the CPA proposed action, and possibly some loss of revenue to facilities supported by recreational fishermen such as boat launches and bait shops.

Recreational Resources: While marine debris and nearshore operations, either individually or collectively, may adversely affect the quality of some recreational experiences, they are unlikely to reduce the number of recreational visits to Gulf Coast beaches. Except for a catastrophic spill such as the DWH event, it is unlikely that a spill would be a major threat to recreational beaches because any impacts would be short term and localized, and should have no long-term effect on tourism.

Historic and Prehistoric Archaeological Resources: The greatest potential impact to an archaeological resource as a result of routine activities associated with the CPA proposed action would result from direct contact between an offshore activity (e.g., platform installation, drilling rig emplacement, and dredging or pipeline project) and a historic or prehistoric site. The archaeological survey and archaeological clearance of sites required prior to an operator beginning oil and gas activities on a lease are expected to be highly effective at identifying possible offshore archaeological sites; however, should such contact occur, there would be damage to or loss of significant and/or unique archaeological information. It is expected that coastal archaeological resources would be protected through the review and approval processes of the various Federal, State, and local agencies involved in permitting onshore activities.

It is not very likely that a large oil spill would occur and contact coastal prehistoric or historic archaeological sites from accidental events associated with the proposed action. Should a spill contact a prehistoric archaeological site, damage might include loss of radiocarbon-dating potential, direct impact from oil-spill cleanup equipment, and/or looting resulting in the irreversible loss of unique or significant archaeological information. The major effect from an oil-spill impact on coastal historic archaeological sites would be visual contamination, which would be temporary and reversible.

Land Use and Coastal Infrastructure: The CPA proposed action would not require additional coastal infrastructure, with the exception of possibly one new gas processing facility and one new pipeline landfall, and it would not alter the current land use of the analysis area. The existing oil and gas infrastructure is expected to be sufficient to handle development associated with the proposed action. There may be some expansion at current facilities, but the land in the analysis area is sufficient to handle such development. There is also sufficient land to construct a new gas processing plant in the analysis area, should it be needed. Accidental events such as oil or chemical spills, blowouts, and vessel collisions would have no effects on land use. Coastal or nearshore spills, as well as vessel collisions, could have short-term adverse effects on coastal infrastructure requiring cleanup of any oil or chemicals spilled.

Demographics: The CPA proposed action is projected to minimally affect the demography of the analysis area. Population impacts from the proposed action are projected to be minimal (<1% of total population) for any economic impact area in the Gulf of Mexico region. The baseline population patterns and distributions, as projected and described in Chapter 3.3.5.4 of the Multisale EIS, are expected to remain unchanged as a result of the proposed action. The increase in employment is expected to be met primarily with the existing population and available labor force with the exception of some in-migration (some of whom may be foreign), which is projected to move into focal areas such as Port Fourchon. Accidental events associated with the proposed action, such as oil or chemical spills, blowouts, and vessel collisions, would have likely no effects on the demographic characteristics of the Gulf coastal communities.

Economic Factors: The CPA proposed action is expected to generate less than a 1 percent increase in employment in any of the coastal subareas, even when the net employment impacts from accidental events are included. Most of the employment related to the proposed action is expected to occur in Texas and Louisiana. The demand would be met primarily with the existing population and labor force.

Environmental Justice: Environmental justice implications arise indirectly from onshore activities conducted in support of OCS exploration, development, and production. Because the onshore infrastructure support system for OCS-related industry (and its associated labor force) is highly developed, widespread, and has operated for decades within a heterogeneous Gulf of Mexico population, the proposed action is not expected to have disproportionately high or adverse environmental or health effects on minority or low-income people. The CPA proposed action would help to maintain ongoing levels of activity rather than expand them. With the exception of a catastrophic accidental event, such as the DWH event, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area.

Soft-Bottom Habitat: The routine activities associated with the CPA proposed action that would impact soft bottoms generally occur within a few hundred meters of platforms, and the greatest impacts are seen close to the platform communities. Although localized impacts to comparatively small areas of the soft-bottom benthic habitats would occur, the impacts would be on a relatively small area of the seafloor compared with the overall area of the seafloor of the CPA (268,922 square kilometers [km^2]; 103,831 square miles [mi^2]). The CPA proposed action is not expected to adversely impact the entire soft-bottom environment because the local impacted areas are extremely small compared with the entire seafloor of the Gulf of Mexico.

Diamondback Terrapins: The routine activities of the CPA proposed action are unlikely to have significant adverse effects diamondback terrapins. Accidental events associated with the proposed action have the potential to impact small to large numbers of terrapins. Due to the extended distance from shore, impacts associated with activities occurring as a result of the CPA proposed action are not expected to impact terrapins or their habitat.

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ABBREVIATIONS AND ACRONYMS

°C	degree Celsius
°F	degree Fahrenheit
2009-2012 Supplemental EIS	*Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218; Final Supplemental Environmental Impact Statement*
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
5-Year Program	*Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012*
ac	acre
ACP	Area Contingency Plans
AL	Alabama
ANPR	Advance Notice of Proposed Rulemaking
APD	Application for Permit to Drill
APE	area of potential effect
API	American Petroleum Institute
ASLM	Assistant Secretary of the Interior for Land and Minerals
BAST	best available and safest technology
bbl	barrel
BBO	billion barrels of oil
Bcf	billion cubic feet
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	blowout preventer
B.P.	before present
BP	British Petroleum
BTEX	benzene, ethylbenzene, toluene, and xylene
CAA	Clean Air Act of 1970
CAAA	Clean Air Act Amendments of 1990
CD	Consistency Determination
CDP	common-depth-point (seismic surveying)
CEEDS	*Complete Economic and Demographic Data Source*
CEI	Coastal Environments, Inc.
CEQ	Council on Environmental Quality
CER	categorical exclusion review
CFR	Code of Federal Regulations
CG	Coast Guard (also: USCG)
CH_4	methane
CIAP	Coastal Impact Assistance Program
cm	centimeter
CMP	Coastal Management Plans
CO	carbon monoxide
CO_2	carbon dioxide
COE	Corps of Engineers (U.S. Army)
COF	covered offshore facilities
CPA	Central Planning Area
CPS	coastal political subdivisions
CRS	Congressional Research Service
CSA	Continental Shelf Associates
CWPPRA	Coastal Wetlands Protection, Planning & Restoration Act
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act

dB	decibel
DOCD	development operations coordination document
DOD	Department of Defense (U.S.)
DOE	Department of Energy (U.S.) (also: USDOE)
DOI	Department of the Interior (U.S.) (also: USDOI)
DOT	Department of Transportation (U.S.) (also: USDOT)
DPP	development and production plan
DWH	*Deepwater Horizon*
DWOP	deepwater operations plan
EA	environmental assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
e.g.	for example
Eh	oxidation reduction potential
EIA	Economic Impact Area
EIS	environmental impact statement
EP	exploration plan
EPA	Eastern Planning Area
EPAct	Energy Policy Act of 2005
ERCO	Energy Resources Co., Inc.
ESA	Endangered Species Act of 1973
ESI	Environmental Sensitivity Indexes
ESP	Environmental Studies Program
ESPIS	Environmental Studies Program Information System
et al.	and others
et seq.	and the following
EWTA	Eglin Water Test Area
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FL	Florida
FPSO	floating production, storage, and offloading system
FR	*Federal Register*
ft	feet
FWS	Fish and Wildlife Service
FY	fiscal year
G&G	geological and geophysical
gal	gallon
GAO	Government Accountability Office (U.S.)
GCCF	Gulf Coast Claims Facility
GERG	Geochemical and Environmental Research Group
GIWW	Gulf Intracoastal Waterway
GMAQS	Gulf of Mexico Air Quality Study
GMFMC	Gulf of Mexico Fishery Management Council
GOADS	Gulfwide Offshore Activities Data System
GOM	Gulf of Mexico
GOMESA	Gulf of Mexico Energy Security Act of 2006
GS	Geological Survey (also: USGS)
H_2S	hydrogen sulfide
ha	hectare
hr	hour
i.e.	specifically
IATAP	Interagency Alternative Technology Assessment Program
in	inch
ITOPF	International Tanker Owners Pollution Federation Limited

ITS	Incidental Take Statement
JIP	Joint Industry Project
kg	kilogram
km	kilometer
kn	knot
LA	Louisiana
LA Hwy 1	Louisiana Highway 1
LACPR	Louisiana Coastal Protection and Restoration
lb	pound
LC_{50}	lethal concentration for 50 percent of the test population
LCA	Louisiana Coastal Area
LMA	labor market area
LMRP	lower marine riser package
LNG	liquefied natural gas
m	meter
MARAD	U.S. Department of Transportation Maritime Administration
MARPOL	International Convention for the Prevention of Pollution from Ships
Mcf	thousand cubic feet
mg	milligram
mg/L	milligrams per liter
mi	mile
ml/L	milliliter per liter
mm	millimeter
MMbbl/d	million barrels per day
MMcf	million cubic feet
MMPA	Marine Mammal Protection Act of 1972
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MODU	mobile offshore drilling unit
MOU	Memorandum of Understanding
mph	miles per hour
MS	Mississippi
Multisale EIS	*Gulf of Mexico OCS Oil and Gas Lease Sales: 2003-2007; Central Planning Area Sales 185, 190, 194, 198, and 201; Western Planning Area Sales 187, 192, 196, and 200; Final Environmental Impact Statement; Volumes I and II*
MWCC	Marine Well Containment Company
N.	north
n.d.	no date
NAAQS	National Ambient Air Quality Standards
NACE	National Association of Corrosion Engineers
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NGMCS	Northern Gulf of Mexico Continental Slope Study
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
nmi	nautical-mile
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent to Prepare an EIS
NOS	National Ocean Service
NPDES	National Pollutant and Discharge Elimination System
NPR	Notice of Proposed Rulemaking

NPS	National Park Service
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
NTL	Notice to Lessees and Operators
NUT	new or unusual technology
O_3	ozone
OBF	oil-based fluids
OBM	oil-based muds
OCD	Offshore and Coastal Dispersion Model
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
ODMDS	ocean dredged-material disposal sites
OIG	Office of the Inspector General
OPA	Oil Pollution Act of 1990
OSFR	oil-spill financial responsibility
OSHA	Occupational Safety and Health Administration
OSRA	Oil Spill Risk Analysis
OSRP	oil-spill response plans
OSV	offshore supply/service vessels
P.L.	Public Law
PAH	polycyclic aromatic hydrocarbon
pH	potential of hydrogen
PINC	Potential Incident of Noncompliance
PM	particulate matter
ppb	part per billion
ppm	parts per million
ppt	parts per thousand
PSD	Prevention of Significant Deterioration
psu	practical salinity unit
QOCSR	qualified OCS revenues
ROD	Record of Decision
ROTAC	Regional Operations Technology Assessment Committee
ROV	remotely operated vehicle
RP	Recommended Practice
RPM	reasonable and prudent measure
RRT	Regional Response Team
RTR	Rigs-to-Reef
S.	south
SAV	submerged aquatic vegetation
SBF	synthetic-based fluids
SBM	synthetic-based muds
SCAT	Shoreline Cleanup and Assessment Team
Secretary	Secretary of the Interior
SEMS	Safety and Environmental Management System
SO_2	sulphur dioxide
SO_x	sulphur oxides
sp.	species
spp.	multiple species
Stat.	Statute
STOF-THPO	Seminole Tribe of Florida-Tribal Historic Preservation Officer
TA&R	Technology Assessment & Research Program
Tcf	trillion cubic feet
TX	Texas
U.S.	United States
U.S.C.	United States Code

UIC	Unified Incident Command
USCG	U.S. Coast Guard (also: CG)
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOE	U.S. Department of the Energy (also: DOE)
USDOI	U.S. Department of the Interior (also: DOI)
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey (also: GS)
VOC	volatile organic compounds
VSP	vertical seismic profiling
W.	west
WAF	water accommodated fraction
WBF	water-based fluids
WPA	Western Planning Area
WSF	water soluble fraction
yd	yard
yr	year

CHAPTER 1

THE PROPOSED ACTION

1. THE PROPOSED ACTION

1.1. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

The purpose of the proposed Federal action is to offer for lease certain Outer Continental Shelf (OCS) blocks located in the Central Planning Area (CPA) in the Gulf of Mexico (GOM) (**Figure 1-1**) that may contain economically recoverable oil and gas resources. Under the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012* (5-Year Program; USDOI, MMS, 2007a), it was proposed that two GOM sales would be held each year—one in the WPA and one in the Central Planning Area (CPA). Proposed consolidated Lease Sale 216/222 in the CPA is the last sale in this planning area of the 5-Year Program and will provide qualified bidders the opportunity to bid on blocks in the Gulf of Mexico OCS in order to explore, develop, and produce oil and natural gas.

This Supplemental Environmental Impact Statement (EIS) was prepared because of the potential changes to baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of (1) the *Deepwater Horizon* (DWH) event between April 20 and July 15, 2010 (the period when oil flowed from the Macondo well in Mississippi Canyon Block 252 [**Figure 1-2**]); (2) the acute impacts that have been reported or surveyed since that time; and (3) any new information that may be available. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments.

The need for the proposed action is to further the orderly development of OCS resources. Oil serves as the feedstock for liquid hydrocarbon products; among them gasoline, aviation and diesel fuel, and various petrochemicals. Oil from the CPA would help reduce the Nation's need for oil imports and lessen a growing dependence on foreign oil. The United States (U.S.) consumed 18.7 million barrels (bbl) of oil per day in 2009 (USDOE, Energy Information Administration, 2010a). Altogether, net imports of crude oil and petroleum products (imports minus exports) accounted for 51 percent of our total petroleum consumption in 2009. The U.S. crude oil imports stood at 9.0 million bbl per day in 2009. Petroleum product imports were 2.7 million bbl per day in 2009. Exports totaled 2.0 million bbl per day in 2009, mainly in the form of distillate fuel oil, petroleum coke, and residual fuel oil. Our biggest supplier of crude oil and petroleum product imports was Canada (21.2%), with countries in the Persian Gulf being the second largest source (17%) in 2009 (USDOE, Energy Information Administration, 2010b). Oil produced from the CPA would reduce the environmental risks associated with transoceanic oil tankering from sources overseas.

In 2009, the U.S. consumed approximately 22.8 trillion cubic feet (Tcf) of natural gas from all sources (USDOE, Energy Information Administration, 2011a). In 2009, the Gulf Coast States used approximately 6.4 Tcf of natural gas (USDOE, Energy Information Administration, 2011a). In 2008, 11.7 percent of U.S. natural gas resources were imported, mostly from Canada (USDOE, Energy Information Administration, 2010c). In 2009, 88 percent of net imports came by pipeline, primarily from Canada, and 12 percent came by liquefied natural gas (LNG) tankers carrying gas from five different countries (USDOE, Energy Information Administration, 2010d). Natural gas is generally considered to be an environmentally preferable alternative to oil, especially when used to generate electricity or for residential and industrial heating. Natural gas is an important feedstock for domestic industries engaged in the manufacture or formulation of fertilizers, pharmaceuticals, plastics, and packaging.

The Outer Continental Shelf Lands Act of 1953 (OCSLA), as amended (43 U.S.C. 1331 et seq. (2008)), established Federal jurisdiction over submerged lands seaward of State boundaries. Under the OCSLA, the Department of the Interior (DOI) is required to manage the leasing, exploration, development, and production of oil and gas resources on the Federal OCS. The Secretary of the Interior (Secretary) oversees the OCS oil and gas program and is required to balance orderly resource development with protection of the human, marine, and coastal environments while simultaneously ensuring that the public receives an equitable return for these resources and that free-market competition is maintained. The OCSLA empowers the Secretary to grant leases to the highest qualified responsible bidder(s) on the basis of sealed competitive bids and to formulate such regulations as necessary to carry out the provisions of the Act. The Secretary has designated the Bureau of Ocean Energy Management,

Regulation and Enforcement (BOEMRE) as the agency responsible for the mineral leasing of submerged OCS lands and for the supervision of offshore operations after lease issuance, in accordance with the provisions of the OCSLA.

At the completion of the National Environmental Policy Act (NEPA) process, the Secretary will decide if proposed CPA Lease Sale 216/222 will be carried out. In the NEPA implementing regulations (40 CFR 1508.28), "tiering" refers to the coverage of general matters in a broader EIS (such as national program) with subsequent narrower statements of environmental analyses (such as regional action). Tiering is appropriate in this instance as broader program issues have already been subjected to analysis, and this Supplemental EIS is more narrowly focused on the site-specific statement or analysis for proposed CPA Lease Sale 216/222. This Supplemental EIS tiers from the following EIS's: the *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement* (5-Year Program EIS; USDOI, MMS, 2007c), which defined the national program; the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Final Environmental Impact Statement* (Multisale EIS; USDOI, MMS, 2007b), which defined the 5-Year Program in the GOM; and the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218, Final Supplemental Environmental Impact Statement* (2009-2012 Supplemental EIS; USDOI, MMS, 2008a), which was required after passage of the Gulf of Mexico Energy Security Act of 2006 (GOMESA).

1.2. DESCRIPTION OF THE PROPOSED ACTION

The proposed action is BOEMRE's holding of the two remaining oil and gas lease sales in the CPA, consolidated as Lease Sale 216/222, as scheduled under the current 5-Year Program. Federal regulations allow for several related or similar proposals to be analyzed in one EIS (40 CFR 1502.4). The BOEMRE has decided to prepare a Supplemental EIS for the remaining CPA lease sales in the 5-Year Program.

Proposed CPA Lease Sale 216/222

Proposed CPA Lease Sale 216/222 is scheduled to be held in 2012. The CPA sale area encompasses about 63 million acres (ac) of the CPA's 66.3 million ac located 3 nautical miles (nmi) (3.4 miles [mi]; 5.5 kilometers [km]) offshore Louisiana, Mississippi, and Alabama and extends seaward to the limits of the Exclusive Economic Zone (EEZ) in water depths up to 3,458 meters (m) (11,345 feet [ft]) (**Figure 1-1**). This proposed CPA lease sale would offer for lease all unleased blocks in the CPA for oil and gas operations, with the following exceptions:

(1) blocks directly south of Florida and within 100 mi (161 km) of the Florida coast (north of the easternmost portion of the proposed CPA lease sale area as shown on **Figure 1-1**); and

(2) blocks that are beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap.

The estimated amount of resources projected to be developed as a result of this proposed CPA lease sale is 0.801-1.624 billion barrels of oil (BBO) and 3.332-6.560 Tcf of gas. The proposed CPA lease sale includes proposed lease stipulations designed to reduce environmental risks and is discussed in **Chapter 2.3**.

1.3. REGULATORY FRAMEWORK

Federal laws mandate the OCS leasing program (i.e., Outer Continental Shelf Lands Act) and the environmental review process (i.e., NEPA). Several Federal statutes and their implementing regulations establish specific consultation and coordination processes with Federal, State, and local agencies (i.e., Coastal Zone Management Act [CZMA], National Historic Preservation Act [NHPA], Endangered Species Act [ESA], the Magnuson-Stevens Fishery Conservation and Management Act, and the Marine Mammal Protection Act [MMPA]). In addition, the OCS leasing process and all activities and operations

on the OCS must comply with other Federal, State, and local laws and regulations. On December 20, 2006, President Bush signed into law GOMESA, which made available two new areas in the GOM for leasing, placed a moratorium on other areas in the GOM, and increased the distribution of offshore oil and gas revenues to coastal States. The following major, applicable Federal laws and regulations are summarized in *OCS Regulatory Framework for the Gulf of Mexico Region* (Matthews and Cameron, 2010):

Regulation or Law	Citation
Outer Continental Shelf Lands Act	43 U.S.C. 1331 et seq.
National Environmental Policy Act of 1969	42 U.S.C. 4321-4347 40 CFR 1500-1508
Coastal Zone Management Act of 1972	16 U.S.C. 1451 et seq., 15 CFR 930.76
Endangered Species Act of 1973	16 U.S.C. 1631 et seq.
Magnuson-Stevens Fishery Conservation and Management Act	16 U.S.C. 1251 et seq.
Essential Fish Habitat	1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act
Essential Fish Habitat Consultation	50 CFR 600.905-930
Marine Mammal Protection Act	16 U.S.C. 1361 et seq.
Clean Air Act	42 U.S.C. 7401 et seq., 40 CFR 55
Clean Water Act	Amendment to Federal Water Pollution Control Act of 1972
Clean Water Act—National Pollutant Discharge Elimination System	Section 316(b) of the Clean Water Act
Harmful Algal Bloom and Hypoxia Research and Control Act	P.L. 105-383
Oil Pollution Act of 1990	33 U.S.C. 2701 et seq., Executive Order 12777
Comprehensive Environmental Response, Compensation, and Liability Act of 1980	42 U.S.C. 9601 et seq.
Resource Conservation and Recovery Act	42 U.S.C. 6901 et seq.
Marine Plastic Pollution Research and Control Act	33 U.S.C. 1901 et seq.
National Fishing Enhancement Act of 1984	33 U.S.C. 2601 et seq.
Fishermen's Contingency Fund	43 U.S.C. 1841-1846
Ports and Waterways Safety Act of 1972	33 U.S.C. 1223 et seq.
Marine and Estuarine Protection Acts	33 U.S.C. 1401 et seq.
Marine Protection, Research, and Sanctuaries Act of 1972	P.L. 92-532
National Estuarine Research Reserves	16 U.S.C. § 1461, Section 315
National Estuary Program	P.L. 104-4
Coastal Barrier Resources Act	16 U.S.C. 3501 et seq.
National Historic Preservation Act	16 U.S.C. 470 et seq.
Rivers and Harbors Act of 1899	33 U.S.C. 401 et seq.
Occupational Safety and Health Act of 1970	29 U.S.C. 651-678q
Energy Policy Act of 2005	P.L. 109-58
Gulf of Mexico Energy Security Act of 2006	P.L. 109-432

Marine Debris Research, Prevention, and Reduction Act	P.L. 109-449
American Indian Religious Freedom Act of 1978	P.L. 95-341, 42 U.S.C. 1996 and 1996a
Federal Aviation Act of 1958	Federal Aviation Act of 1958 was repealed by the recodification of 49 U.S.C. (P.L. 103-272)
Migratory Bird Treaty Act of 1918	16 U.S.C. 703-712; Ch. 128; 07/13/1918; 40 Stat. 755
Submerged Lands Act of 1953	43 U.S.C. §§ 1301-1315 (2002)
49 U.S.C. 44718: Structures Interfering with Air Commerce	49 U.S.C. 44718
U.S. Coast Guard Regulations	
Marking of Obstructions	
Executive Order 11988: Floodplain Management	42 FR 26951 (1977), amended by Executive Order 12148 (7/20/79)
Executive Order 11990: Protection of Wetlands	42 FR 26961 (1977), amended by Executive Order 12608 (9/9/87)
Executive Order 12114: Environmental Effects Abroad	44 FR 1957 (1979)
Executive Order 12898: Environmental Justice	59 FR 5517 (1994)
Executive Order 13007: Indian Sacred Sites	61FR26771-26772(1996)
Executive Order 13089: Coral Reef Protection	63FR32701-32703(1998)
Executive Order 13175: Consultation and Coordination with Indian Tribal Governments	65 FR 67249-67252 (2000)
Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds	66 FR 3853 (2001)

1.3.1. Rule Changes following the *Deepwater Horizon* Event

In the aftermath of the DWH event on April 20, 2010, President Obama directed the Secretary of the Interior (“Secretary”) to report within 30 days on what, if any, additional precautions, technologies, and procedures should be required on the OCS to improve the safety of oil and gas development on the OCS. In response to this directive, the Department of the Interior (DOI) prepared the report, *Increased Safety Measures for Energy Development on the Outer Continental Shelf*. The “30-Day Report” or “Safety Measures Report” was delivered to the Secretary and made public on May 27, 2010 (USDOI, 2010).

On a separate track and beginning long before the DWH event, this Agency published an Advanced Notice of Proposed Rulemaking (ANPR) (*Federal Register*, 2006a) on May 22, 2006, to solicit ideas for adoption of the American Petroleum Institute (API) Recommended Practice (RP) 75 containing recommended practice for development of a Safety and Environmental Management System (SEMS) for OCS operations and facilities (API, 2004). This Agency published a Notice of Proposed Rulemaking (NPR) on June 17, 2009 (*Federal Register*, 2009a), based on comments received on the 2006 ANPR. The Agency was in the process of finalizing the rule when the DWH event took place. The final rule (*Federal Register*, 2010a) was published on October 15, 2010, requiring full implementation of a SEMS program as recommended by API RP 75.

On May 28, 2010, the Secretary directed this Agency to exercise its authority under the OCSLA to suspend certain drilling activities in water depths of 500 ft (152 m) and deeper for a period of up to 6 months. The May 28th suspension was intended to provide sufficient time to (1) ensure that drilling operations similar to conditions that apply to the DWH event operate in a safe manner when drilling resumes, (2) account for the expected timeline for killing the Macondo well so that the extensive spill response resources directed toward the spill would start to become available for other spill events, and (3) provide adequate time to obtain input from ongoing investigations of the accident and to develop and promulgate regulations that address issues described in the Safety Measures Report.

On June 22, 2010, the United States Federal District Court in the Eastern District of Louisiana enjoined enforcement of the May 28th suspension. On July 12, 2010, the Secretary issued a decision

memorandum rescinding the May 28th suspension and imposing a second suspension of certain drilling operations in deep water that was originally announced to be effective until November 30, 2010. In particular, the July 12th suspension applied, with certain exceptions, to the drilling of wells using a subsea blowout preventer (BOP) or a surface BOP on a floating facility. Three primary issues supported this temporary pause in drilling operations. The suspension (1) allowed time for BOEMRE to implement appropriate workplace and drilling safety measures; (2) was intended to provide BOEMRE, the industry, and others time to develop strategies and methods of containment of wild wells in deep water; and (3) was necessary to ensure that appropriate and sufficient response resources would be available in the event of another major oil spill.

The BOEMRE reduced the duration of the July 12, 2010, suspension insofar as it applies to deepwater development drilling operations using a subsea BOP or a surface BOP on a floating facility and wrote an environmental assessment with a Finding of No Significant Impact (USDOI, BOEMRE, 2010a). On October 12, 2010, the July 12 suspension was lifted in its entirety. After October 12, 2010, BOEMRE began to review and potentially approve pending and future applications for permits to drill deepwater development wells using a subsea BOP or a surface BOP on a floating facility. Operators are still required to complete the documentation required to certify to BOEMRE that they are ready to re-initiate their projects.

The BOEMRE has addressed the three issues posed in the July 12, 2010, activity suspension through multiple venues. The BOEMRE has collected a large amount of information through public hearings and other meetings held specifically on the DWH event and through public comments on rulemaking efforts. The information collection, review, and analysis efforts resulted in new regulations, planned Notices to Lessees and Operators (NTL's) and BOEMRE procedures that address drilling safety, oil-spill response, and enhanced inspection procedures. These regulations, NTL's, and procedures were not in effect at the time of the DWH event, but they will apply to all future applicable drilling activities. The regulations, NTL's, and procedures include the following:

- NTL 2010-N05, "Increased Safety Measures for Energy Development," effective June 8, 2010 ("Safety NTL").
- NTL 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS," effective June 18, 2010 ("Plans NTL").
- NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," effective November 8, 2010 ("Certification NTL").
- The Drilling Safety Rule, Interim Final Rule to Enhance Safety Measures for Energy Development on the Outer Continental Shelf ("Drilling Safety Rule") (*Federal Register,* 2010b). This rule strengthens requirements for safety equipment, well control systems, and blowout prevention practices on offshore oil and gas operations.
- The Workplace Safety Rule on Safety and Environmental Management Systems ("SEMS Rule") (*Federal Register,* 2010a). This rule requires operators to develop and implement a comprehensive SEMS for identifying, addressing, and managing operational safety hazards and impacts; promoting both human safety and environmental protection; and improving workplace safety by reducing the risk of human error.
- Enhanced Inspection Procedures. The BOEMRE is developing plans and schedules for conducting safety inspections of all deepwater drilling facilities. These plans and schedules will be implemented upon the recommencement of deepwater drilling operations.

Drilling Safety Rule

The BOEMRE determined issuance of an interim rule was needed; this rule would implement the recommendations from the 30-Day Report considered by the Secretary to be the most important for safe resumption of offshore drilling operations. On October 14, 2010, the interim final rule was published in the *Federal Register* (2010b) together with a discussion of the comments that had been received by the Secretary in the period leading up to promulgation of the rule. The interim rulemaking revises selected sections of 30 CFR 250 Subparts D, E, F, O, and Q. Only a portion of the proposed changes in Subpart D will add material capital or operating costs (some of which will be significant). For example, identical costly new requirements for subsea function testing of remotely operated vehicle (ROV) intervention during drill operations (Subpart D) also apply to well completion (Subpart E) and workover (Subpart F) operations.

Table 1-1 compares the previous 30 CFR 250 Subpart D requirements with the new regulations. Those changes that will impose significant costs include (1) seafloor function testing of ROV intervention and deadman systems (30 CFR 250.449(j) and (k), 30 CFR 250.516(d) and 250.616(h)); (2) negative pressure testing of individual casing strings (30 CFR 250.423(c)); (3) use of dual mechanical barriers for the final casing string (30 CFR 250.420(b)); (4) professional engineer certification that the well design is appropriate for expected wellbore conditions (30 CFR 250.420(a)); (5) retrieval and testing of BOP after a shear ram has been activated in a well-control situation (30 CFR 250.451(i)); and (6) third-party certification that the shear rams will shear drill pipe under maximum anticipated pressure (30 CFR 250.416(e)).

Subsea ROV and Deadman Function Testing—Drilling

Previous regulations at 30 CFR 250.449(b) required a stump test of the subsea BOP system. In a stump test, the subsea BOP system is placed on a simulated wellhead (the stump) on the rig floor. The BOP system is tested on the stump to ensure that the BOP is functioning properly. The new regulatory section at 30 CFR 250.449(j) requires that all ROV intervention functions on the subsea BOP stack must be tested during the stump test and one set of rams must be tested by an ROV on the seafloor.

Autoshear and deadman control systems activate during an accidental disconnect or loss of power, respectively. The new regulatory section at 30 CFR 250.449(k) requires that the autoshear and deadman systems be function-tested during the stump test, and the deadman system tested during the initial test on the seafloor. The initial test on the seafloor is performed as soon as the BOP is attached to the subsea wellhead.

These new requirements will confirm that a well will be secured in an emergency situation and prevent a possible loss of well control. The ROV test requirement will ensure that the dedicated ROV has the capacity to close the BOP functions on the seafloor. The deadman-switch test on the seafloor verifies that the wellbore closes automatically if both hydraulic pressure and electrical communication are lost with the rig.

The initial test on the seafloor for one set of rams and the deadman system is not currently an industry standard practice and will incur lost rig time. The addition of autoshear and deadman systems stump testing will incur additional rig time, but we do not expect the ROV intervention function stump testing to significantly increase testing time. Some operators currently simulate the hydraulic flow of an ROV to function test the BOP stack, while others use an actual ROV to test the BOP stack; this regulation will require the use of an ROV during the stump test.

The BOEMRE conducted a survey to investigate the potential impact of subsea ROV testing. Several drilling contractors, lease operators, and equipment manufacturers were asked: "How long would it take to function test the ROV to verify that the ROV could be used to close one set of blind-shear rams, one set of pipe rams, and disconnect the lower marine riser package (LMRP)?" Results averaged about 24 hours of lost rig time to perform these subsea tests. However, the interim regulation only requires one set of rams and the deadman system to be tested on the seafloor, not disconnecting the LMRP. The LMRP disconnect is estimated to require more time than testing the deadman system alone. We did not ask about the autoshear and deadman stump test requirements in our survey. We estimate that performing both the autoshear and deadman stump tests take close to the same time required to test the LMRP

seafloor disconnect. The regulation will not affect platform rigs or shallow wells since they do not use subsea BOP's or ROV's.

Subsea ROV Function Testing—Workover/Completions

Previous regulations did not require subsea ROV function testing of the BOP during workover or completions operations. The new regulatory sections 30 CFR 250.516(d)(8) and 250.616(h)(1) require testing of ROV intervention functions and the autoshear/deadman systems during the stump test, and a function test of at least one set of rams and the deadman system on the seafloor. These sections extend the requirements added to deepwater drilling operations (discussed in the previous section) to well completion operations and workover operations using a subsea BOP stack. Successful exploratory wells are typically temporarily abandoned until additional equipment is installed to produce the reservoir. When the operator is preparing to produce the well, it is often completed using a different rig or redeployment of the original rig. The BOEMRE data show that two-thirds of deepwater wells drilled are exploratory wells, and approximately 23 percent of exploratory wells are completed.

Negative Pressure Tests

Previous regulation at 30 CFR 250.423 required a positive pressure test for each string of casing, except for the drive or structural casing string. This test confirms that fluid from the casing string is not flowing into the formation. The new regulatory section at 30 CFR 250.423(c) requires that a negative pressure test be conducted for all intermediate and production casing strings. This test will reveal whether gas or fluid from outside the casing is flowing into the well and ensures that the casing and cement provide a seal. Maintenance of pressure under both tests ensures proper casing installation and the integrity of the casing and cement. Based on in-house expertise, we estimate each new negative pressure test will take approximately 90 minutes for each casing string. We also estimate that, on average, deepwater wells use one production and four intermediate casing strings and that shallow wells use one production and two intermediate casing strings.

Installation of Dual Mechanical Barriers

Previous regulations did not require the installation of dual mechanical barriers. The new regulatory section at 30 CFR 250.420(b)(3) requires the operator install dual mechanical barriers in addition to cement barriers for the final casing string. These barriers prevent hydrocarbon flow in the event of cement failure at the bottom of the well. The operator must document the installation of the dual mechanical barriers and submit this documentation to BOEMRE within 30 days after installation. These new requirements will ensure that the best casing and cementing design will be used for a specific well. Dual mechanical barriers may include two float valves or one float valve and one mechanical plug. Based on in-house expertise, BOEMRE estimates that all wells will require a second mechanical barrier.

Professional Engineer Certification for Well Design

Previous regulations at 30 CFR 250.420(a) specified well casing and cementing requirements but did not require verification by a Registered Professional Engineer. The new regulatory section at 30 CFR 250.420(a)(6) (modified October 14, 2010) requires that well casing and cementing specifications must be certified by a Registered Professional Engineer. The Registered Professional Engineer will verify that the well casing and cementing design is appropriate for the purpose for which it is intended under expected wellbore conditions. This verification will add assurance that the appropriate design is used for the well, thus decreasing the likelihood of a blowout.

Emergency Cost of Activated Shear Rams

Previous regulations did not address BOP inspection following use of the blind-shear ram or casing shear ram. The new regulatory section at 30 CFR 250.451(i) requires that, if a blind-shear ram or casing shear ram is activated in a well control situation where the pipe is sheared, the BOP stack must be retrieved, fully inspected, and tested. This provision will ensure the integrity of the BOP and that the

BOP will still function and hold pressure after the event. This activity, when triggered, will add about 13 days to drilling time. According to a Det Norske Veritas study, out of 5,611 deepwater wells, there were 12 situations where either the blind-shear or casing shear ram was activated; this implies one activation for every 515 wells drilled.

Third-Party Shearing Verification

Regulation 30 CFR 250.416(e) requires information verifying that BOP blind-shear rams are capable of cutting through any drill pipe in the hole under maximum anticipated conditions. This regulation has been modified to require the BOP verification be conducted by an independent third party. The independent third party provides an objective assessment that the blind-shear rams can shear any drill pipe in the hole if the shear rams are functioning properly. This confirmation will be required for both subsea and surface BOP's. NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," clarifies how the regulations apply to operators conducting operations using subsea BOP's or surface BOP's on floating facilities. The NTL informs these operators that a statement, signed by an authorized company official stating that the operator will conduct all authorized activities in compliance with all applicable regulations, including the increased safety measures regulations, should be submitted with each application for a well permit.

30 CFR 250 Subpart S—Safety and Environmental Management System (SEMS)

Following the DWH event, BOEMRE promulgated a final rule that requires operators to develop and implement a SEMS for OCS operations (*Federal Register*, 2010a). As explained in a BOEMRE fact sheet (USDOI, BOEMRE, 2010b), a SEMS is a comprehensive management program for identifying, addressing, and managing operational safety hazards and impacts, with the goal of promoting both human safety and environmental protection. The SEMS program rule is a workplace safety program rule covering all offshore oil and gas operations in Federal waters and makes mandatory the previously voluntary practices in the API RP 75. A mandatory oil and gas SEMS program is intended to enhance the safety and environmental protection of oil and gas drilling operations on the OCS. The SEMS Rule is implemented in the new Subpart S of 30 CFR 250.1900-1915. The Final Rule became effective on November 15, 2010, and needs to be implemented by November 15, 2011.

This Agency was preparing to finalize the SEMS Workplace Safety Rule before the DWH event. During the DWH event, BOEMRE continued to carefully analyze the proposed rule, which proposed making mandatory the essential components of API RP 75. The BOEMRE has determined that it agrees with comments from some reviewers urging BOEMRE to incorporate all of API RP 75. The BOEMRE intends to address additional safety management system provisions considered appropriate in light of the DWH event in additional future rulemakings.

The BOEMRE believes that finalizing the Workplace Safety Rule has the following benefits. It will (1) provide oversight and enforcement of SEMS provisions (Although many large operators on the OCS currently have a SEMS program, the voluntary nature of the programs limits their effectiveness.); (2) impose the requirement for a SEMS program on all OCS operators; (3) address human factors behind accidents not reached by previous regulations; and (4) provide a flexible approach to systematic safety that can keep up with evolving technologies.

The 13 elements of API RP 75 that 30 CFR 250 Subpart S now make mandatory are as follows:

- defining the general provisions for implementation, planning and management review, and approval of the SEMS program;
- identifying safety and environmental information needed for any facility such as design data, facility process such as flow diagrams, and mechanical components such as piping and instrument diagrams;
- requiring a facility-level risk assessment;
- addressing any facility or operational changes including management changes, shift changes, contractor changes;

- evaluating operations and written procedures;
- specifying safe work practices, manuals, standards, and rules of conduct;
- training, safe work practices, and technical training, including contractors;
- defining preventive maintenance programs and quality control requirements;
- requiring a pre-startup review of all systems;
- responding to and controlling emergencies, evacuation planning, and oil-spill contingency plans in place and validated by drills;
- investigating incidents, procedures, corrective action, and follow-up;
- requiring audits every 4 years, to an initial 2-year reevaluation and then subsequent 3-year audit intervals; and
- specifying records and documentation that describes all elements of the SEMS program.

1.4. PRELEASE PROCESS

Scoping for this Supplemental EIS was conducted in accordance with Council Environmental Quality (CEQ) regulations implementing NEPA. Scoping provides those with an interest in the OCS Program an opportunity to provide comments on the proposed action. In addition, scoping provides BOEMRE an opportunity to update the Gulf of Mexico OCS Region's environmental and socioeconomic information base. The public scoping process for this Supplemental EIS began November 10, 2010, with publication of the Notice of Intent to Prepare a Supplemental EIS (NOI) and an announcement for three scoping meetings (*Federal Register*, 2010c). A 45-day comment period was established. A subsequent NOI was published in the *Federal Register* on November 16, 2010, to correct clerical errors in the first notice, and it established January 3, 2011, for the closing of the comment period (*Federal Register*, 2010d). Between the first and second NOI's, the dates and locations for scoping meetings announced on November 10, 2010, did not change.

Although the scoping process for the current 5-Year Program was formally initiated on March 7, 2006, with the publication of the NOI in the *Federal Register*, scoping efforts and other coordination meetings have proceeded and will continue to proceed throughout this NEPA process. Scoping and coordination opportunities are available during BOEMRE's requests for information, comments, input, and review on other BOEMRE NEPA documents.

The Area Identification decision was made for all proposed lease sales in the current 5-Year Program on August 10, 2006. The Area Identification is an administrative prelease step that describes the geographical area of the proposed action (proposed lease sale area) and identifies the alternatives, mitigating measures, and issues to be analyzed in the appropriate NEPA document. As mandated by NEPA, this Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments.

Scoping meetings were held on November 16 in New Orleans at the Louis Armstrong Airport Hilton, on November 17 in Houston at the George Bush Airport Marriott, and on November 18 in Mobile at the Battle House Renaissance Mobile Hotel. Public notices were published on November 12 and 13, 2010, the weekend before the meetings, in these local papers: the *Times Picayune*; the *Houston Chronicle*; and the *Mobile Register*. Announcements were sent by U.S. mail to addressees on BOEMRE's Gulf of Mexico mailing list and were posted on the Internet. Letters were sent to the Governor's of the five Gulf Coast States announcing the scoping process on November 10, 2010. Federal, State, and local governments, along with other interested parties, were invited to send written comments to the Gulf of Mexico OCS Region on the scope of the Supplemental EIS. Comments were received in response to the NOI, and testimony was provided at the scoping meetings from Federal, State, local government agencies, interest groups, industry, businesses, and the general public on the scope of the Supplemental EIS, significant issues that should be addressed, alternatives that should be considered, and mitigation

measures. All scoping meeting comments received were considered in the preparation of this Supplemental EIS. The comments (both verbal and written) have been summarized in **Chapter 5.3**.

The BOEMRE also conducted early coordination with appropriate Federal and State agencies and other concerned parties to discuss and coordinate the prelease process for the proposed lease sale and this Supplemental EIS. Key agencies and organizations included the U.S. Department of Commerce, National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS); U.S. Department of Defense (USDOD or DOD); U.S. Coast Guard (USCG or CG); U.S. Environmental Protection Agency (USEPA); State Governors' offices; and industry groups.

The BOEMRE is providing copies of this Draft Supplemental EIS for review and comment to public and private agencies, interest groups, and local libraries. To initiate the public review and comment period on this Draft Supplemental EIS, BOEMRE will publish a Notice of Availability (NOA) in the *Federal Register*. Additionally, public notices will be mailed with this Draft Supplemental EIS and placed on the BOEMRE, Gulf of Mexico OCS Region's Internet website. In accordance with 30 CFR 256.26, BOEMRE will hold public hearings to solicit comments on this Draft Supplemental EIS. The hearings provide the Secretary with information from interested parties to help in the evaluation of potential effects of the proposed lease sale. Notices of the public hearings will be included in the NOA, posted on the BOEMRE, Gulf of Mexico OCS Region's Internet website, and published in the *Federal Register* and local newspapers.

A consistency review will be performed and a Consistency Determination (CD) will be prepared for each affected State prior to the proposed lease sale. To prepare the CD's, BOEMRE reviews each State's Coastal Management Program (CMP) and analyzes the potential impacts as outlined in this Supplemental EIS, new information, and applicable studies as they pertain to the enforceable policies of each CMP. Based on the analyses, the BOEMRE Director makes an assessment of consistency, which is then sent to each State with the Proposed Notice of Sale (NOS). If a State objects with BOEMRE's CD, the State is required to do the following under CZMA: (1) indicate how BOEMRE's presale proposal is inconsistent with specific enforceable policies of the CMP (specify the enforceable policy with citation); (2) describe alternative measures (if they exist) to bring BOEMRE's proposal into consistency with their CMP; or (3) describe the nature of the information requested and the necessity of such information to determine the consistency of the Federal agency activity with the enforceable policies of the management program. Unlike the consistency process for specific OCS plans and permits, there is not a procedure for administrative appeal to the Secretary of Commerce for a Federal CD for presale activities. In the event of a serious disagreement between a Federal agency and the State CMP regarding consistency of the proposed lease sale, either BOEMRE or the State may request mediation. The regulations provide for an opportunity to resolve any differences with the State, but CZMA allows BOEMRE to proceed with the lease sale despite any unresolved disagreements if the Federal agency clearly describes, in writing, to the State CMP how the activity is consistent to the maximum extent practicable.

The Final Supplemental EIS will be published approximately 5 months prior to the proposed lease sale. To initiate the public review and 30-day minimum comment period on the Final Supplemental EIS, BOEMRE will publish a NOA in the *Federal Register*. The BOEMRE will provide copies of the Final Supplemental EIS for review and comment to public and private agencies, interest groups, and local libraries. Additionally, public notices will be mailed with the Final Supplemental EIS and placed on the BOEMRE, Gulf of Mexico OCS Region's Internet website.

After the end of the comment period, DOI will review the Supplemental EIS in consideration of all comments received on the Final Supplemental EIS. The Supplemental EIS is not a decision document. A Record of Decision (ROD), which is the last step in this Supplemental EIS process, will be published before the sale is scheduled. The ROD will summarize the proposed action and the alternatives evaluated in the Supplemental EIS, the conclusions of the impact analyses, and other information considered in reaching the decision. All comments received on the Final Supplemental EIS will be addressed in the ROD.

A Proposed NOS will become available to the public 4-5 months prior to the proposed lease sale. A notice announcing the availability of the Proposed NOS appears in the *Federal Register*, initiating a 60-day comment period. Comments received will be analyzed during preparation of the decision documents that are the basis for the Final NOS, including proposed lease sale configuration and terms and conditions.

If the decision by the Assistant Secretary of the Interior for Land and Minerals (ASLM) is to hold the proposed lease sale, a Final NOS will be published in its entirety in the *Federal Register* at least 30 days prior to the sale date, as required by the OCSLA. If the ASLM determines that the proposed lease sale will not move forward, then the Final NOS will not be published.

1.5. Postlease Activities

The BOEMRE is responsible for managing, regulating, and monitoring oil and natural gas exploration, development, and production operations on the Federal OCS to promote orderly development of mineral resources and to prevent harm or damage to, or waste of, any natural resource, any life or property, or the marine, coastal, or human environment. Regulations for oil, gas, and sulphur lease operations are specified in 30 CFR 250, 30 CFR 251, and 30 CFR 254.

Measures to mitigate potential impacts are an integral part of the OCS Program. These measures are implemented through lease stipulations, operating regulations, NTL's, and project-specific requirements or approval conditions. Mitigating measures address concerns such as endangered and threatened species, geologic and manmade hazards, military warning and ordnance disposal areas, archaeological sites, air quality, oil-spill response planning, chemosynthetic communities, artificial reefs, operations in hydrogen sulfide (H_2S) prone areas, and shunting of drill effluents in the vicinity of biologically sensitive features. Standard mitigation measures in the Gulf of Mexico OCS include

- limiting the size of explosive charges used for structure removals;
- requiring placement explosive charges at least 15 ft (5 m) below the mudline;
- requiring site-clearance procedures to eliminate potential snags to commercial fishing nets;
- establishment of No Activity and Modified Activity Zones around high-relief live bottoms;
- requiring remote-sensing surveys to detect and avoid biologically sensitive areas such as low-relief live bottoms, pinnacles, and chemosynthetic communities; and
- requiring coordination with the military to prevent multiuse conflicts between OCS and military activities.

The BOEMRE issues NTL's to provide clarification, description, or interpretation of a regulation; guidelines on the implementation of a special lease stipulation or regional requirement; or convey administrative information. A detailed listing of current Gulf of Mexico OCS Region NTL's is available through the BOEMRE, Gulf of Mexico OCS Region's Internet website or through the Region's Public Information Office at (504) 736-2519 or 1-800-200-GULF.

Formal plans must be submitted to BOEMRE for review and approval before any project-specific activities, except for ancillary activities (such as geological and geophysical activities or studies that model potential oil and hazardous substance spills), can begin on a lease. Conditions of approval are mechanisms to control or mitigate potential safety or environmental problems associated with proposed operations. Conditions of approval are based on BOEMRE technical and environmental evaluations of the proposed operations. Comments from Federal and State agencies (as applicable) are also considered in establishing conditions. Conditions may be applied to any OCS plan, permit, right-of-use of easement, or pipeline right-of-way grant.

Some BOEMRE-identified mitigation measures are implemented through cooperative agreements or coordination with the oil and gas industry and Federal and State agencies. These measures include the NOAA Fisheries Service Observer Program to protect marine mammals and sea turtles when OCS structures are removed using explosives, labeling of operational supplies to track sources of accidental debris loss, development of methods of pipeline landfall to eliminate impacts to barrier beaches, and semiannual beach cleanup events.

The following postlease activity descriptions apply to the proposed lease sale area in the CPA.

Geological and Geophysical Activities

A geological and geophysical (G&G) permit must be obtained from BOEMRE prior to conducting off-lease geological or geophysical exploration or scientific research on unleased OCS lands or on lands under lease to a third party (30 CFR 251.4 (a) and (b)). Geological investigations include various seafloor sampling techniques to determine the geochemical, geotechnical, or engineering properties of the sediments.

Ancillary activities are defined in 30 CFR 250.105 with regulations outlined in 30 CFR 250.207 through 250.210. Ancillary activities are activities conducted on-lease and include G&G exploration and development G&G activities; geological and high-resolution geophysical, geotechnical, archaeological, biological, physical oceanographic, meteorological, socioeconomic, or other surveys; or various types of modeling studies. This Agency issued NTL 2009-G34, "Ancillary Activities," to provide updated guidance and clarification on conducting ancillary activities in BOEMRE's Gulf of Mexico OCS Region. Operators should notify the BOEMRE, Gulf of Mexico OCS Region, Regional Supervisor, Field Operations in writing 30 days in advance before conducting any of the following types of ancillary activities:

- involving the use of an airgun or airgun array in water depths 200 m (656 ft) or greater, or in the Eastern Planning Area (EPA) of the GOM in any water depth;
- independent of water depth, involving the use of explosives as an energy source; and
- independent of water depth, including ocean-bottom cable surveys, node surveys, and time-lapse (4D) surveys.

Additionally, NTL 2009-G34 clarifies that the Gulf of Mexico OCS Region, Regional Supervisor, Field Operations should be notified in writing 15 days in advance before conducting the following types of ancillary activities:

- involving the use of an airgun or airgun array in water depths 200 m (656 ft) or greater, or in the EPA of the GOM in any water depth;
- involving bottom disturbance, independent of water depth, including ocean-bottom cable surveys, node surveys, and time-lapse (4D) surveys; and
- a geotechnical evaluation involving piston-/gravity-coring or the recovery of sediment specimens by grab-sampling or similar technique and/or any dredging or other ancillary activity that disturbs the seafloor (including deployment and retrieval of bottom cables, anchors, or other equipment).

This NTL also provides guidance for each type of ancillary activity, the type and level of BOEMRE review, and follow-up, post-survey report requirements.

Seismic surveys are performed to obtain information on surface and near-surface geology and on subsurface geologic formations. Low-energy, high-resolution seismic surveys collect data on surficial geology used to identify potential shallow geologic or manmade hazards (e.g., faults or pipelines) for engineering and site planning for bottom-founded structures. The high-resolution surveys are also used to identify environmental and archaeological resources such as low-relief live-bottom areas, pinnacles, chemosynthetic community habitat, and shipwrecks. High-energy, deep-penetration, common-depth-point (CDP) seismic surveys obtain data about geologic formations thousands of feet below the seafloor. The two-dimensional (2D) and three-dimensional (3D) CDP data are used to map structure features of stratigraphically important horizons in order to identify potential hydrocarbon traps. They can also be used to map the extent of potential habitat for chemosynthetic communities. In some situations, a set of 3D surveys can be run over a time interval to produce a four-dimensional (4D), or "time-lapse," survey that could be used to characterize production reservoirs.

This Agency completed a programmatic environmental assessment (EA) on Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico OCS (CSA, 2004a). Upon receiving a complete G&G permit application, BOEMRE conducts a categorical exclusion review (CER),

an EA, or an EIS in accordance with the G&G Programmatic EA's conclusions, NEPA guidelines, and other applicable BOEMRE policies. When required under an approved coastal management program, proposed G&G permit activities must receive State concurrence prior to BOEMRE permit approval.

Exploration and Development Plans

To ensure conformance with the OCSLA, other laws, applicable regulations, and lease provisions, and to enable BOEMRE to carry out its functions and responsibilities, formal plans (30 CFR 250.211 and 250.241) with supporting information must be submitted for review and approval by BOEMRE before an operator may begin exploration, development, or production activities on any lease. Supporting environmental information, archaeological reports, biological reports (monitoring and/or live-bottom survey), and other environmental data determined necessary must be submitted with an OCS plan. This information provides the basis for an analysis of both offshore and onshore impacts that may occur as a result of the activities. The BOEMRE may require additional specific supporting information to aid in the evaluation of the potential environmental impacts of the proposed activities. The BOEMRE can require amendment of an OCS plan based on inadequate or inaccurate supporting information. The 30 CFR 250 Subpart B regulations were revised to update the information that must be submitted and were published in the *Federal Register* on August 30, 2005 (70 FR 167).

The OCS plans are reviewed by geologists, geophysicists, engineers, biologists, archaeologists, air quality specialists, oil-spill specialists, NEPA coordinators, and/or environmental scientists. The plans and accompanying information are evaluated to determine whether any seafloor or drilling hazards are present; that air and water quality issues are addressed; that plans for hydrocarbon resource conservation, development, and drainage are adequate; that environmental issues and potential impacts are properly evaluated and mitigated; and that the proposed action is in compliance with NEPA, CZMA, BOEMRE operating regulations, and other requirements. Federal agencies, including the U.S. Fish and Wildlife Service (FWS), NOAA Fisheries Service, USEPA, the U.S. Navy, the U.S. Air Force, and the USCG, may be consulted if the proposal has the potential to impact areas under their jurisdiction. Each Gulf Coast State has a designated CZM agency that takes part in the review process. The OCS plans are also made available to the general public for comment through the BOEMRE, Gulf of Mexico OCS Region's Public Information Office.

In response to increasing deepwater activities in the GOM, BOEMRE developed a comprehensive strategy to address NEPA compliance and environmental issues in the deepwater areas. A key component of that strategy was the completion of a Programmatic EA to evaluate the potential effects of the deepwater technologies and operations (USDOI, MMS, 2000). As a supplement to the Programmatic EA, this Agency prepared a series of technical papers that provide a summary description of the different types of structures that may be employed in the development and production of hydrocarbon resources in the deepwater areas of the GOM (Regg et al., 2000). The Programmatic EA and technical papers were used in the preparation of this Supplemental EIS.

On the basis of the BOEMRE reviews of the OCS plan, the findings of the proposal-specific CER, EA, or EIS, and other applicable BOEMRE studies and NEPA documents, the OCS plan is approved or disapproved by BOEMRE, or modified and resubmitted. Although very few OCS plans are ultimately disapproved, many must be amended prior to approval to fully comply with BOEMRE operating regulations and requirements, or other Federal laws, to address reviewing agencies' concerns, or to avoid potential hazards or impacts to environmental resources.

On May 12, 2008, this Agency issued NTL 2008-G06, "Remotely Operated Vehicle (ROV) Surveys in Deepwater." The NTL provides guidance for ROV surveys and reports in water depths greater than 400 m (1,312 ft). Twenty-one grid areas have been developed to ensure a broad and systematic analysis of deep water and to depict areas of biological similarity, primarily on the basis of benthic communities. The grid areas cover the WPA and CPA. Grids 18, 19, 20, and 21 have been designated as deepwater and ultra-deepwater grids (**Figure 1-3**).

Operators must submit a ROV survey plan with each Exploration Plan (EP) submitted in each grid area and with the Development Operations Coordination Document (DOCD) for the first surface structure proposed in each grid area. The DOCD is a document that must be prepared by the operator and submitted to BOEMRE for approval before any development or production activities are conducted on a lease in the Western Gulf. The following information must be included in a ROV survey plan:

- a statement that the operator is familiar with the ROV survey and reporting provisions outlined in the NTL;
- a brief description of the survey the operator plans to conduct, including timeframes, proposed transects, and the equipment that will be used; and
- a statement that the operator will make biological and physical observations as described in the NTL and the ROV survey form during two periods of operations—pre-spudding (survey performed from the facility) and post-drilling (prior to facility removal).

A minimum of five surveys will be required for each grid area. The BOEMRE will notify the operator whether or not to conduct the proposed ROV survey based on whether the grid area has already received adequate ROV survey coverage (as documented at http://www.gomr.boemre.gov/homepg/regulate/environ/ea_grid/ea_grid.asp).

Exploration Plans

An EP must be submitted to BOEMRE for review and decision before any exploration activities, except for preliminary activities (such as hazard surveys or geophysical surveys), can begin on a lease. The EP describes exploration activities, drilling rig or vessel, proposed drilling and well-testing operations, environmental monitoring plans, and other relevant information, and includes a proposed schedule of the exploration activities. Guidelines and environmental information requirements for lessees and operators submitting an EP are addressed in 30 CFR 250.211 and are further explained in NTL's 2008-G04, "Shallow Hazards Program," and 2009-G27, "Submitting Exploration Plans and Development Operations Coordination Documents." The NTL 2008-G04 provides guidance on information requirements and establishes the contents for OCS plans required by 30 CFR 250 Subpart B. The NTL 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS," effective June 18, 2010, rescinded the limitations set forth in NTL 2008-G04 regarding a blowout and worse-case discharge scenarios and provided national guidance regarding the content of information in a blowout and worse-case discharge scenario descriptions. The NTL 2009-G27 clarifies guidance for submitting OCS plans and DOCD's to the BOEMRE, Gulf of Mexico OCS Region.

After receiving an EP, BOEMRE determines if the plan is complete and adequate before technical and environmental reviews. The BOEMRE evaluates the proposed exploration activities for potential impacts relative to geohazards and manmade hazards (including existing pipelines), archaeological resources, endangered species, sensitive biological features, water and air quality, oil-spill response, State CZMA requirements, and other uses (e.g., military operations) of the OCS. The EP is reviewed for compliance with all applicable laws and regulations.

A CER or EA is prepared as documentation of the environmental review of the EP. The CER or EA is based on available information, which may include the geophysical report (for determining the potential for the presence of deepwater benthic communities); archaeological report; air emissions data; live-bottom survey and report; biological monitoring plan; and recommendations by the affected State(s), DOD, FWS (for selected plans under provisions of a DOI agreement), NOAA Fisheries Service, and/or internal BOEMRE offices. As part of the review process, each EP must contain a certification of consistency and the necessary data and information for the State to determine that the proposed activities comply with the enforceable policies of the States' approved CMP and that such activities will be conducted in a manner that is consistent with the CMP (16 U.S.C. 1456 (c)(3)(A) and 15 CFR 930.76).

If the EP is approved, and prior to conducting drilling operations, the operator is required to submit and obtain approval for an Application for Permit to Drill (APD) (see *Wells* under *Permits and Applications* below).

Deepwater Operations Plans

In 1992, this Agency formed an internal Deepwater Task Force to address technical issues and regulatory concerns relating to deepwater (>1,000 ft; 305 m) operations and projects utilizing subsea

technology. Based on the Deepwater Task Force's recommendation, an NTL (2000-N06) was at first developed that was incorporated into 30 CFR 250 Subpart B. The revisions to Subpart B were finalized August 30, 2005, and required operators to submit a Deepwater Operations Plan (DWOP) for all operations in deep water (400 m [1,312 ft] or greater) and all projects using subsea technology. DeepStar, an industry-wide cooperative workgroup focused on deepwater regulatory issues and critical technology development issues, worked closely with this Agency's Deepwater Task Force to develop the initial guidelines for the DWOP. The DWOP was established to address regulatory issues and concerns that were not addressed in the existing BOEMRE regulatory framework, and it is intended to initiate an early dialogue between BOEMRE and industry before major capital expenditures on deepwater and subsea projects are committed. Deepwater technology has been evolving faster than BOEMRE's ability to revise OCS regulations; the DWOP was established through the NTL process, which provides for a more timely and flexible approach to keep pace with the expanding deepwater operations and subsea technology.

The DWOP is intended to address the different functional requirements of production equipment in deep water, particularly the technological requirements associated with subsea production systems, and the complexity of deepwater production facilities. The DWOP provides BOEMRE with information specific to deepwater equipment issues to demonstrate that a deepwater project is being developed in an acceptable manner as mandated in the OCSLA, as amended, and the BOEMRE operating regulations at 30 CFR 250. The BOEMRE reviews deepwater development activities from a total system perspective, emphasizing operational safety, environmental protection, and conservation of natural resources. The DWOP process is a phased approach that parallels the operator's state of knowledge about how a field will be developed. A DWOP outlines the design, fabrication, and installation of the proposed development/production system and its components. A DWOP will include structural aspects of the facility (fixed, floating, subsea); station-keeping (includes mooring system); wellbore, completion, and riser systems; safety systems; product removal or offtake systems; and hazards and operability of the production system. The DWOP provides BOEMRE with the information to determine that the operator has designed and built sufficient safeguards into the production system to prevent the occurrence of significant safety or environmental incidents. The DWOP, in conjunction with other permit applications, provides BOEMRE the opportunity to assure that the production system is suitable for the conditions in which it will operate.

This Agency recently completed a review of several industry-developed, recommended practices that address the mooring and risers for floating production facilities. The recommended practices address such things as riser design, mooring system design (station-keeping), and hazard analysis. Hazard analyses allow BOEMRE to be assured that the operator has anticipated emergencies and is prepared to address them, either through their design or through the operation of the equipment in question. This Agency released these clarifications of its requirements in recent NTL's: NTL 2009-G03, "Synthetic Mooring Systems"; NTL 2009-G11, "Accidental Disconnect of Marine Drilling Risers"; and NTL 2009-G13, "Guidelines for Tie-downs on OCS Production Platforms for Upcoming Hurricane Seasons."

Conservation Reviews

One of BOEMRE's primary responsibilities is to ensure development of economically producible reservoirs according to sound conservation, engineering, and economic practices as cited in 30 CFR 250.202(c), 250.203, 250.204, 250.205, 250.210, 250.296, 250.297, 250.298, 250.299, and 250.1101. Operators should submit the necessary information as part of their EP, initial and supplemental DOCD, and Conservation Information Document. Conservation reviews are performed to ensure that economic reserves are fully developed and produced, and that there is no harm to the ultimate recovery.

Development Operations and Coordination Documents

Before any development operations can begin on a lease in the proposed lease sale area, a DOCD must be submitted to BOEMRE for review and decision. A DOCD describes the proposed development activities, drilling activities, platforms or other facilities, proposed production operations, environmental monitoring plans, and other relevant information, and it includes a proposed schedule of development and production activities. Requirements for lessees and operators submitting a DOCD are addressed in 30 CFR 250.241-250.242, and information guidelines for DOCD's are provided in NTL's 2008-G04, 2009-G27, and 2010-N06.

After receiving a DOCD, BOEMRE performs technical and environmental reviews. The BOEMRE evaluates the proposed activity for potential impacts relative to geohazards and manmade hazards (including existing pipelines), archaeological resources, endangered species, sensitive biological features, water and air quality, oil-spill response, State CZMA requirements, and other uses (e.g., military operations) of the OCS. The DOCD is reviewed for compliance with all applicable laws and regulations.

A CER, EA, and/or EIS are prepared as documentation of the environmental review of a DOCD. The CER, EA, and/or EIS are based on available information, which may include the geophysical report (for determining the potential for the presence of deepwater benthic communities); archaeological report; air emissions data; live-bottom survey and report; biological monitoring plan; and recommendations by the affected State(s), DOD, FWS (for selected plans under provisions of a DOI agreement), NOAA Fisheries Service, and/or internal BOEMRE offices.

As part of the review process, the DOCD and related environmental analysis may be sent to the affected State(s) for a consistency review under the States' federally approved coastal management program. The OCSLA (43 U.S.C. 1345(a) through (d) and 43 U.S.C. 1351(a)(3)) and CZMA (16 U.S.C. 1456 (c)(3)(A) and 15 CFR 930.76) provide for this coordination and consultation with the affected State and local governments concerning a DOCD.

New or Unusual Technologies

Technologies continue to evolve to meet the technical, environmental, and economic challenges of deepwater development. New or unusual technologies (NUT's) may be identified by the operator in its EP, DWOP, and DOCD or through BOEMRE's plan review processes. Some of the technologies proposed for use by the operators are actually extended applications of existing technologies and interface with the environment in essentially the same way as well-known or conventional technologies. These technologies are reviewed by BOEMRE for alternative compliance or departures that may trigger additional environmental review. Some examples of new technologies that do not affect the environment differently and that are being deployed in the OCS Program are synthetic mooring lines, subsurface safety devices, and multiplex subsea controls.

Some new technologies differ in how they function or interface with the environment. These include equipment or procedures that have not been installed or used in Gulf of Mexico OCS waters. Having no operational history, they have not been assessed by BOEMRE through technical and environmental reviews. New technologies may be outside the framework established by BOEMRE regulations and, thus, their performance (safety, environmental protection, efficiency, etc.) has not been addressed by BOEMRE. The degree to which these new technologies interface with the environment and the potential impacts that may result are considered in determining the level of NEPA review that would be initiated.

The BOEMRE has developed a NUT's matrix to help facilitate decisions on the appropriate level of engineering and environmental review needed for a proposed technology. Technologies will be added to the NUT's matrix as they emerge, and technologies will be removed from the matrix as sufficient experience is gained in their implementation. From an environmental perspective, the matrix characterizes new technologies into three components: technologies that may affect the environment; technologies that do not interact with the environment any differently than "conventional" technologies; and technologies that BOEMRE does not have sufficient information to determine its potential impacts to the environment. In this later case, BOEMRE will seek to gain the necessary information from operators or manufacturers regarding the technologies to make an appropriate determination on its potential effects on the environment.

Alternative Compliance and Departures: The BOEMRE's project-specific engineering safety review ensures that equipment proposed for use is designed to withstand the operational and environmental condition in which it would operate. When an OCS operator proposes the use of technology or procedures not specifically addressed in established BOEMRE regulations, the operations are evaluated for alternative compliance or departure determination. Any new technologies or equipment that represent an alternative compliance or departure from existing BOEMRE regulation must be fully described and justified before it would be approved for use. For BOEMRE to grant alternative compliance or departure approval, the operator must demonstrate an equivalent or improved degree of protection as specified in 30 CFR 250.141. Comparative analysis with other approved systems, equipment, and procedures is one tool that BOEMRE uses to assess the adequacy of protection provided by alternative technology or

operations. Actual operational experience is necessary with alternative compliance measures before BOEMRE would consider them as proven technology.

Emergency Plans

Criteria, models, and procedures for shutdown operations and the orderly evacuation for a pending hurricane have been in place in the Gulf of Mexico OCS for more than 30 years. (Such emergency plans are different from the oil-spill response plans described later in this chapter.) Operating experience from extensive drilling activities and more than 4,000 platforms during the 30-plus years of the Gulf of Mexico OCS Program have demonstrated the effectiveness and safety of securing wells and evacuating a facility in advance of severe weather conditions. Preinstallation efforts, historical experience with similar systems, testing, and the actual operating experience (under normal conditions and in response to emergency situations) are used to formulate the exact time needed to secure the wells and production facility and to evacuate it as necessary. Operators develop site-specific curtailment, securing, and evacuation plans that vary in complexity and formality by operator and type of activity. In general terms, all plans are intended to make sure the facility (or well) is secured in advance of a pending storm or developing emergency. The operating procedures developed during the engineering, design, and manufacturing phases of the project, coupled with the results (recommended actions) from hazard analyses performed, will be used to develop the emergency action and curtailment plans. Evacuation and production curtailment must consider a combination of factors, including the well status (drilling, producing, etc.) and the type and mechanics of wellbore operations. These factors are analyzed onsite through a decisionmaking process that involves onsite facility managers. The emphasis is on making real-time, situation-specific decisions and forecasting based on available information. Details of the shut-in criteria and various alerts are addressed on a case-by-case basis.

Plans for shutting in production from the subsea wells are addressed as part of the emergency curtailment plan. The plan specifies the various alerts and shutdown criteria linked to both weather and facility performance data, with the intent to have operations suspended and the wells secured in the event of a hurricane or emergency situation. Ensuring adequate time to safely and efficiently suspend operations and secure the well is a key component of the planning effort. Clearly defined responsibilities for the facility personnel are part of the successful implementation of the emergency response effort.

For a severe weather event such as a hurricane, emergency curtailment plans would address the criteria and structured procedures for suspending operations and ultimately securing the wellbore(s) prior to weather conditions that could exceed the design operating limitations of the drilling or production unit. For drilling operations, the plan might also address procedures for disconnecting and moving the drilling unit off location after the well has been secured, should the environmental conditions exceed the floating drilling unit’s capability to maintain station. Curtailment of operations consists of various stages of “alerts” indicating the deterioration of meteorological, oceanographic, or wellbore conditions. Higher alert levels require increased monitoring, the curtailment of lengthy wellbore operations, and, if conditions warrant, the eventual securing of the well. If conditions improve, operations could resume based on the limitations established in the contingency plan for the known environmental conditions. The same emergency curtailment plans would be implemented in an anticipated or impending emergency situation, such as the threat of a terrorist attack.

Neither BOEMRE nor USCG mandates that an operator must evacuate a production facility for a hurricane; it is a decision that rests solely with the operator. The USCG does require the submittal of an emergency evacuation plan that addresses the operator’s intentions for evacuation of nonessential personnel, egress routes on the production facility, lifesaving and personnel safety devices, firefighting equipment, etc. As activities move farther from shore, it may become safer to not evacuate the facility because helicopter operations become inherently more risky with greater flight times. Severe weather conditions also increase the risks associated with helicopter operations. The precedent for leaving a facility manned during severe weather is established in the North Sea and other operating basins.

Redundant, fail-safe, automatic shut-in systems located inside the wellbore and at the sea surface, and in some instances at the seafloor, are designed to prevent or minimize pollution. These systems are designed and tested to ensure proper operation should a production facility or well be catastrophically damaged. Testing occurs at regular intervals with predetermined performance limits designed to ensure functioning of the systems in case of an emergency. After the DWH event, the testing requirements for

well control systems came under immediate scrutiny in the DOI Secretary's "Safety Measures Report" that was delivered to him on May 27, 2010. The Safety Measures Report included a recommendation of a program of immediate recertification of BOP's. As stated above, the new regulatory section at 30 CFR 250.451(i) requires that, if a blind-shear ram or casing shear ram is activated in a well-control situation where the pipe is sheared, the BOP stack must be retrieved, fully inspected, and tested (*Federal Register*, 2010b). This and other new regulations that improve safety in the event of an emergency are described above in **Chapter 1.3.1**.

Permits and Applications

After EP or DOCD approval, the operator submits applications for specific activities to BOEMRE for approval. These applications include those for drilling wells; well-test flaring; temporary well abandonment; installing a well protection structure, production platforms, satellite structures, subsea wellheads and manifolds, and pipelines; installation of production facilities; commencing production operations; platform removal and lease abandonment; and pipeline decommissioning.

Wells

The BOEMRE requirements for the drilling of wells can be found at 30 CFR 250 Subpart D. Lessees are required to take precautions to keep all wells under control at all times. The lessee must use the best available and safest technology to enhance the evaluation of abnormal pressure conditions and to minimize the potential for uncontrolled well flow.

Prior to conducting drilling operations, the operator is required to submit and obtain approval for an APD. The APD requires detailed information—including project layout at a scale of 24,000:1, design criteria for well control and casing, specifications for blowout preventers, a mud program, cementing program, directional drilling plans, etc.—to allow evaluation of operational safety and pollution-prevention measures. The APD is reviewed for conformance with the engineering requirements and other technical considerations.

The BOEMRE is responsible for conducting technical and safety reviews of all drilling, workover, and production operations on the OCS. These detailed analyses determine if the lessee's proposed operation is in compliance with all regulations and all current health, safety, environmental, and classical engineering standards.

The BOEMRE regulations at 30 CFR 250.1710-1717 address the requirements for permanent abandonment of a well on the OCS. A permanent abandonment includes the isolation of zones in the open wellbore, plugging of perforated intervals, plugging the annular space between casings (if they are open), setting a surface plug, and cutting and retrieving the casing at least 15 ft (5 m) below the mudline. All plugs must be tested in accordance with the regulations. There are no routine surveys of permanently abandoned well locations. If a well were found to be leaking, BOEMRE would require the operator of record to perform an intervention to repair the abandonment. If a well is temporarily abandoned at the seafloor, an operator must provide BOEMRE with an annual report summarizing plans to permanently abandon the well or to bring the well into production.

Platforms and Structures

The BOEMRE does a technical review of all proposed structure designs and installation procedures. All proposed facilities are reviewed for structural integrity. These detailed engineering reviews entail an evaluation of all operator proposals for fabrication, installation, modification, and repair of all mobile and fixed structures. The lessee must design, fabricate, install, use, inspect, and maintain all platforms and structures on the OCS to assure their structural integrity for the safe conduct of operations at specific locations. Applications for platform and structure approval are filed in accordance with 30 CFR 250.901. Design requirements are presented in detail at 30 CFR 250.904 through 250.909. The lessee evaluates characteristic environmental conditions associated with operational functions to be performed. Factors such as waves, wind, currents, tides, temperature, and the potential for marine growth on the structure are considered. In addition, pursuant to 30 CFR 250.902 and 250.903, a program has been established by BOEMRE to assure that new structures meeting the conditions listed under 30 CFR 250.900(c) are designed, fabricated, and installed using standardized procedures to prevent structural failures. This

program facilitates review of such structures and uses third-party expertise and technical input in the verification process through the use of a Certified Verification Agent. After installation, platforms and structures are required to be periodically inspected and maintained under 30 CFR 250.912.

Pipelines

Regulatory processes and jurisdictional authority concerning pipelines on the OCS and in coastal areas are shared by several Federal agencies, including DOI, Department of Transportation (DOT), U.S. Army Corps of Engineers (COE), the Federal Energy Regulatory Commission (FERC), and the USCG. Aside from pipeline regulations, these agencies have the responsibility of overseeing and regulating the following areas: the placement of structures on the OCS and pipelines in areas that affect navigation; the certification of proposed projects involving the transportation or sale of interstate natural gas, including OCS gas; and the right of eminent domain exercised by pipeline companies onshore. In addition, DOT is responsible for promulgating and enforcing safety regulations for the transportation in interstate commerce of natural gas, liquefied natural gas (LNG), and hazardous liquids by pipeline. This includes, for the most part, offshore pipelines on State lands beneath navigable waters and on the OCS that are operated by transmission companies. The regulations are contained in 49 CFR 191 through 193 and 195. In a Memorandum of Understanding (MOU) between DOT and DOI dated December 10, 1996, each party's respective regulatory responsibilities are outlined. The DOT is responsible for establishing and enforcing design, construction, operation, and maintenance regulations, and for investigating accidents for all OCS transportation pipelines beginning downstream of the point at which operating responsibility transfers from a producing operator to a transporting operator. The DOI's responsibility extends upstream from the transfer point described above.

The BOEMRE is responsible for regulatory oversight of the design, installation, and maintenance of OCS producer-operated oil and gas pipelines. The BOEMRE operating regulations for pipelines found at 30 CFR 250 Subpart J are intended to provide safe and pollution-free transportation of fluids in a manner that does not unduly interfere with other users of the OCS. Pipeline applications are usually submitted and reviewed separately from DOCD's. Pipeline applications may be for on-lease pipelines or rights-of-way for pipelines that cross other lessees' leases or unleased areas of the OCS. Pipeline permit applications to BOEMRE include the pipeline location drawing, profile drawing, safety schematic drawing, pipe design data, a shallow hazard survey report, and an archaeological report, if applicable.

The DOI has regulatory responsibility for all producer-operated pipelines. The DOI's responsibility extends downstream from the first production well to the last valve and associated safety equipment on the last OCS-related production system along the pipeline. The DOT's regulatory responsibility extends shoreward from the last valve on the last OCS-related production facility.

The BOEMRE evaluates the design, fabrication, installation, and maintenance of all OCS pipelines. Proposed pipeline routes are evaluated for potential seafloor or subsea geologic hazards and other natural or manmade seafloor or subsurface features or conditions (including other pipelines) that could have an adverse impact on the pipeline or that could be adversely impacted by the proposed operations. Routes are also evaluated for potential impacts on archaeological resources and biological communities. A NEPA review is conducted in accordance with applicable policies and guidelines. The BOEMRE prepares an EA on all pipeline rights-of-way that go ashore. For Federal consistency, applicants must comply with the regulations as clarified in NTL 2007-G20, "Coastal Zone Management Program Requirements for OCS Right-of-way Pipeline Applications." All Gulf States require consistency review of right-of-way pipeline applications as described in the clarifying NTL.

The design of the proposed pipeline is evaluated for an appropriate cathodic protection system to protect the pipeline from leaks resulting from the effects of external corrosion of the pipe; an external pipeline coating system to prolong the service life of the pipeline; measures to protect the inside of the pipeline from the detrimental effects, if any, of the fluids being transported; the submersibility of the line (i.e., that the pipeline will remain in place on the seafloor and not have the potential to float, even if empty or filled with gas rather than liquids); proposed operating pressure of the line; and protection of other pipelines crossing the proposed route. Such an evaluation includes the following: (1) reviewing the calculations used by the applicant in order to determine whether the applicant properly considered such elements as the grade of pipe to be used, the wall thickness of the pipe, derating factors (the practice of operating a component well inside its normal operating limits to reduce the rate at which the component

deteriorates), related to the submerged and riser portions of the pipeline, the pressure rating of any valves or flanges to be installed in the pipeline, the pressure rating of any other pipeline(s) into which the proposed line might be tied, and the required pressure to which the line must be tested before it is placed in service; (2) protective safety devices such as pressure sensors and remotely operated valves, the physical arrangement of those devices proposed to be installed by the applicant for the purposes of protecting the pipeline from possible overpressure conditions and for detecting and initiating a response to abnormally low-pressure conditions; and (3) the applicant's planned compliance with regulations requiring that pipelines installed in water depths less than 200 ft (61 m) be buried to a depth of at least 3 ft (1 m). In addition, pipelines crossing fairways require a COE permit and must be buried to a depth of at least 10 ft (3 m) and to 16 ft (5 m) if crossing an anchorage area.

Operators are required to periodically inspect pipeline routes. Monthly overflights are conducted to inspect pipeline routes for leakage.

Applications for pipeline decommissioning must also be submitted for BOEMRE review and approval. Decommissioning applications are evaluated to ensure they will render the pipeline inert and/or to minimize the potential for the pipeline becoming a source of pollution by flushing and plugging the ends and to minimize the likelihood that the decommissioned line will become an obstruction to other users of the OCS by filling it with water and burying the ends.

Inspection and Enforcement

The OCSLA authorizes and requires BOEMRE to provide for both an annual scheduled inspection and a periodic unscheduled (unannounced) inspection of all oil and gas operations on the OCS. The inspections are to assure compliance with all regulatory constraints that allowed commencement of the operation.

The primary objective of an initial inspection is to assure proper installation of mobile drilling units and fixed structures, and proper functionality of their safety and pollution prevention equipment. After operations begin, additional announced and unannounced inspections are conducted. Unannounced inspections are conducted to foster a climate of safe operations, to maintain a BOEMRE presence, and to focus on operators with a poor performance record. These inspections are also conducted after a critical safety feature has previously been found defective. Poor performance generally means that more frequent, unannounced inspections may be conducted on a violator's operation.

The annual inspection examines all safety equipment designed to prevent blowouts, fires, spills, or other major accidents. These annual inspections involve the inspection for installation and performance of all facilities' safety-system components.

The inspectors follow the guidelines as established by the regulations, API RP 14C, and the specific BOEMRE-approved plan. The BOEMRE inspectors perform these inspections using a national checklist called the Potential Incident of Noncompliance (PINC) list. This list is a compilation of yes/no questions derived from all regulated safety and environmental requirements.

The BOEMRE administers an active civil penalties program (30 CFR 250 Subpart N). A civil penalty in the form of substantial monetary fines may be issued against any operator that commits a violation that may constitute a threat of serious, irreparable, or immediate harm or damage to life, property, or the environment. The BOEMRE may make recommendations for criminal penalties if a willful violation occurs. In addition, the regulation at 30 CFR 250.173(a) authorizes suspension of any operation in the GOMR if the lessee has failed to comply with a provision of any applicable law, regulation, or order or provision of a lease or permit. Furthermore, the Secretary may invoke his authority under 30 CFR 250.185(c) to cancel a nonproductive lease with no compensation. Exploration and development activities may be canceled under 30 CFR 250.182 and 250.183.

Pollution Prevention, Oil-Spill Response Plans, and Financial Responsibility

Pollution Prevention

Pollution prevention is addressed through proper design and requirements for safety devices. The BOEMRE regulations at 30 CFR 250.400 require that the operator take all necessary precautions to keep its wells under control at all times. The lessee is required to use the best available and safest drilling technology in order to enhance the evaluation of conditions of abnormal pressure and to minimize the

potential for the well to flow or kick. Redundancy is required for critical safety devices that will shut off flow from the well if loss of control is encountered. A complete description of rule changes implemented as a result of the DWH event is detailed in **Chapter 1.3.1**.

In addition, BOEMRE regulations at 30 CFR 250 Subparts E, F, and H require that the lessee assure the safety and protection of the human, marine, and coastal environments during completion, workover, and production operations. All production facilities, including separators, treaters, compressors, headers, and flowlines are required to be designed, installed, tested, maintained, and used in a manner that provides for efficiency, safety of operations, and protection of the environment. Wells, particularly subsea wells, include a number of sensors that help in detecting pressures and the potential for leaks in the production system. Safety devices are monitored and tested frequently to ensure their operation, should an incident occur. To ensure that safety devices are operating properly, BOEMRE incorporates the API RP 14C into the operating regulations. The API RP 14C incorporates the knowledge and experience of the oil and gas industry regarding the analysis, design, installation, and testing of the safety devices used to prevent pollution. The API RP 14C presents proven practices for providing these safety devices for offshore production platforms. Proper application of these practices, along with good design, maintenance, and operation of the entire production facility, should provide an operationally safe and pollution-free production platform.

Also, BOEMRE regulations at 30 CFR 250 Subpart J require that pipelines and associated valves, flanges, and fittings be designed, installed, operated, and maintained to provide safe and pollution-free transportation of fluids in a manner that does not unduly interfere with other uses on the OCS.

The BOEMRE regulation at 30 CFR 250.300(a) requires that lessees not create conditions that will pose an unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean during offshore oil and gas operations. The lessee is required to take measures to prevent the unauthorized discharge of pollutants into the offshore waters. Control and removal of pollution is the responsibility and at the expense of the lessee. Immediate corrective action to an unauthorized release is required. All hydrocarbon-handling equipment for testing and production, such as separator and treatment tanks, are required to be designed, installed, and operated to prevent pollution. Maintenance and repairs that are necessary to prevent pollution are required to be taken immediately. Drilling and production facilities are required to be inspected daily or at intervals approved or prescribed by the BOEMRE District Supervisor to determine if pollution is occurring.

Operators are required to install curbs, gutters, drip pans, and drains on platform and rig deck areas in a manner necessary to collect all greases, contaminants, and debris not authorized for discharge. The rules also explicitly prohibit the disposal of equipment, cables, chains, containers, or other materials into offshore waters. Portable equipment, spools or reels, drums, pallets, and other loose items must be marked in a durable manner with the owner’s name prior to use or transport over offshore waters. Smaller objects must be stored in a marked container when not in use. Operational discharges such as produced water and drilling muds and cuttings are regulated by USEPA through the National Pollutant Discharge Elimination System (NPDES) permit program. The BOEMRE may restrict the rate of drilling fluid discharge or prescribe alternative discharge methods. No petroleum-based substances, including diesel fuel, may be added to the drilling mud system without prior approval of the BOEMRE District Supervisor.

Blowout Preventers

A blowout preventer (BOP) is a complex of choke lines and hydraulic rams mounted atop the well head that can seal off the casing of a well by remote control at the surface. There are different types of BOP’s. A pipe ram closes on the drill pipe by pinching it, but it cannot seal on open hole. A blind ram is a straight-edged rams used to close an open hole. The BOP’s were invented in the early-1920’s and have been instrumental in ending dangerous, costly, and environmentally damaging oil gushers. The BOP’s have been required for OCS oil and gas operations from the time offshore drilling began in the late 1940’s. There are two types: ram and annular (also called spherical). Rams were deployed in the 1920’s and annular preventers in the 1950’s. Rams are designed to seal an open hole by closing the wellbore with a sharp horizontal motion that may cut through casing or tool strings, as a last resort. An annular BOP closes around the drill string in a smooth simultaneous upward and inward motion. Both types are usually used together to create redundancy in a BOP stack. Because BOP’s are important for the safety of

the drilling crew, as well as the rig and the wellbore itself, BOP's are regularly inspected, tested, and refurbished. The BOP's are actuated as a last resort upon imminent threat to the integrity of the well or the surface rig (**Chapter 3.2.2**). New regulations for BOP's were published on October 14, 2010, as described in **Chapter 1.3.1** (*Federal Register,* 2010b).

Oil-Spill Response Plans

The BOEMRE's responsibilities under the Oil Pollution Act of 1990 (OPA) include spill prevention, review, and approval of oil-spill response plans (OSRP's); inspection of oil-spill containment and cleanup equipment; and ensuring oil-spill financial responsibility for facilities in offshore waters located seaward of the coastline or in any portion of a bay that is connected to the sea either directly or through one or more other bays. The BOEMRE regulations (30 CFR 254) require that all owners and operators of oil-handling, storage, or transportation facilities located seaward of the coastline submit an OSRP for approval. The term "coastline" means the line of ordinary low water along that portion of the coast that is in direct contact with the open sea and the line marking the seaward limit of inland waters. The term "facility" means any structure, group of structures, equipment, or device (other than a vessel), which is used for one or more of the following purposes: exploring for; drilling for; producing; storing; handling; transferring; processing; or transporting oil. A mobile offshore drilling unit (MODU) is classified as a facility when engaged in drilling or downhole operations.

The regulation at 30 CFR 254.2 requires that an OSRP must be submitted and approved before an operator can use a facility. The BOEMRE can grant an exception to this requirement during the BOEMRE review of an operator's submitted OSRP. In order to be granted this exception during this time period, an owner/operator must certify in writing to BOEMRE that it is capable of responding to a "worst-case" spill or the substantial threat of such a spill. To continue operations, the facility must be operated in compliance with the approved OSRP or the BOEMRE-accepted "worst-case" spill certification. Owners or operators of offshore pipelines are required to submit an OSRP for any pipeline that carries oil, condensate, or gas with condensate; pipelines carrying essentially dry gas do not require an OSRP. Current OSRP's are required for abandoned facilities until they are physically removed or dismantled.

The OSRP describes how an operator intends to respond to an oil spill. The OSRP may be site-specific or regional (30 CFR 254.3). The term "regional" means a spill response plan that covers multiple facilities or leases of an owner or operator, including affiliates, which are located in the same BOEMRE GOM region. The subregional plan concept is similar to the regional concept, which allows leases or facilities to be grouped together for the purposes of (1) calculating response times, (2) determining quantities of response equipment, (3) conducting oil-spill trajectory analyses, (4) determining worst-case discharge scenarios, and (5) identifying areas of special economic and environmental importance that may be impacted and the strategies for their protection. The number and location of the leases and facilities allowed to be covered by a subregional OSRP will be decided by BOEMRE on a case-by-case basis considering the proximity of the leases or facilities proposed to be covered. NTL 2006-G21 includes guidance on the preparation and submittal of subregional OSRP's.

The Emergency Response Action Plan within the OSRP serves as the core of the BOEMRE-required OSRP. In accordance with 30 CFR 254, the Emergency Response Action Plan requires identification of (1) the qualified individual and the spill-response management team, (2) the spill-response operating team, (3) the oil-spill cleanup organizations under contract for response, and (4) the Federal, State, and local regulatory agencies that an owner/operator must notify or that they must consult with to obtain site-specific environmental information when an oil spill occurs. The OSRP is also required to include an inventory of appropriate equipment and materials, their availability, and the time needed for deployment, as well as information pertaining to dispersant use, in situ burning, a worst-case discharge scenario, contractual agreements, and training and drills. The response plan must provide for response to an oil spill from their facility and the operator must immediately carry out the provisions of the plan whenever an oil spill from the facility occurs. The OSRP must be in compliance with the National Contingency Plan and the Area Contingency Plan(s) (ACP). The operator is also required to carry out the training, equipment testing, and periodic drills described in the OSRP. All BOEMRE-approved OSRP's must be reviewed at least every 2 years. In addition, revisions must be submitted to BOEMRE within 15 days whenever

(1) a change occurs that appreciably reduces an owner/operator's response capabilities;

(2) a substantial change occurs in the worst-case discharge scenario or in the type of oil being handled, stored, or transported at the facility;

(3) there is a change in the name(s) or capabilities of the oil-spill removal organizations cited in the OSRP; or

(4) there is a change in the applicable ACP's.

As a result of the DWH event, although BOEMRE is not requiring the submission of revised OSRP's at this time, the Agency will provide guidance regarding additional information that operators should submit regarding spill response and surface containment in light of the "worst case" discharge calculations that are now required by the regulations and as clarified in NTL 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS," which became effective on June 18, 2010. This NTL provides clarification of the regulations requiring a lessee or operator to submit supplemental information for new or previously submitted EP's, development and production plans (DPP's), or DOCD's. The required supplemental information includes the following: (1) a description of the blowout scenario as required by 30 CFR 250.213(g) and 250.243(h); (2) a description of their assumptions and calculations used in determining the volume of the worst-case discharge required by 30 CFR 250.219(a)(2)(iv) (for EP's) or 30 CFR 250.250(a)(2)(iv) (for DPP's and DOCD's); and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed. The early intervention methods could actually include the surface and subsea containment resources that BOEMRE announced in NTL 2010-N10, which states that BOEMRE will begin reviewing to ensure that the measures are adequate to promptly respond to a blowout or other loss of well control.

Additionally, to address new improved containment systems, NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," became effective on November 8, 2010. This NTL applies only to operators conducting operations using subsea or surface BOP's on floating facilities. It clarifies the regulations that lessees and operators submit a statement signed by an authorized company official with each application for a well permit, indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations at 75 FR 63346. The NTL also informs lessees that BOEMRE will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. Although the NTL does not provide that operators submit revised Oil Spill Response Plans (OSRP's) that include this containment information at this time, operators were notified of BOEMRE's intention to evaluate the adequacy of each operator to comply in the operator's current OSRP; therefore, there is an incentive for voluntary compliance.

Financial Responsibility

The responsible party for covered offshore facilities (COF's) may have to demonstrate oil spill financial responsibility (OSFR), as required by 30 CFR 253. These regulations implement the OSFR requirements of Title I of OPA, as amended. Penalties for noncompliance with these requirements are covered at 30 CFR 250.51 and in NTL 2008-N05, "Guidelines for Oil Spill Financial Responsibility for Covered Facilities." A COF, as defined in 30 CFR 253.3, is any structure and all of its components (including wells completed at the structure and the associated pipelines), equipment, pipeline, or device (other than a vessel or other than a pipeline or deepwater port licensed under the Deepwater Port Act of 1974) used for exploring, drilling, or producing oil, or for transporting oil from such facilities. The BOEMRE ensures that each responsible party has sufficient funds for removal costs and damages resulting from the accidental release of liquid hydrocarbons into the environment for which the responsible party is liable.

Air Emissions

The OCSLA (43 U.S.C. 1334(a)(8)) requires the Secretary of the Interior to promulgate and administer regulations that comply with the National Ambient Air Quality Standards (NAAQS), pursuant to the Clean Air Act (CAA) (42 U.S.C. 7401 et seq.), to the extent that authorized activities significantly affect the air quality of any State. Under provisions of the CAA Amendments (CAAA) of 1990, the USEPA Administrator has jurisdiction and, in consultation with the Secretary of the Interior and the Commandant of the Coast Guard, established the requirements to control air pollution in OCS areas of the Pacific, Atlantic, Arctic, and eastward of 87.5^{o} W. longitude in the GOM. Air quality in the OCS area westward of 87.5^{o} W. longitude in the Gulf is under BOEMRE jurisdiction.

For OCS air emission sources located east of 87.5^{o} W. longitude and within 25 mi (40 km) of the States' seaward boundaries, the requirements are the same as would be applicable if the source were located in the corresponding onshore area. The USEPA requirements for these OCS areas are at 40 CFR 55, Appendix A. For air emission sources located east of 87.5^{o} W. longitude and more than 25 mi (40 km) from the States' seaward boundaries, sources are subject to Federal requirements for Prevention of Significant Deterioration (PSD). The USEPA regulations also establish procedures that allow the USEPA Administrator to exempt any OCS source from an emissions control requirement if it is technically infeasible or poses unreasonable threat to health or safety.

The BOEMRE issued NTL 2009-N11 to clarify that BOEMRE's regulatory authority and the implementing regulations in 30 CFR Subpart C apply only to those air emission sources in the Gulf of Mexico westward of 87.5º W. longitude. The regulated pollutants include carbon monoxide, suspended particulates, sulphur dioxide, nitrogen oxides, total hydrocarbons, and volatile organic compounds. All new or supplemental EP's and DOCD's must include air emissions information sufficient to determine whether an air quality review is required (30 CFR 250.218 and 250.49). The BOEMRE regulations can require a review of air quality emissions to determine if the projected emissions from a facility result in onshore ambient air concentrations above BOEMRE significance levels and to identify appropriate emissions controls to mitigate potential onshore air quality degradation.

The BOEMRE uses a two-level hierarchy of evaluation criteria to evaluate potential impacts of offshore emission sources to onshore areas. The evaluation criteria are the exemption level and the significance level. If the proposed activities exceed the criteria at the first (exemption) level, the evaluation moves to the significance level criteria. The initial evaluation compares the worst-case emissions to the BOEMRE exemption criteria. This corresponds to the USEPA screening step, where the proposed activity emissions are checked against the screening thresholds or "exemption levels." If the proposed activity emissions are below the exemption levels, the proposed action is exempt from further air quality review.

If exemption levels are exceeded, then the second step requires refined modeling using the Offshore and Coastal Dispersion (OCD) Model. The results from the OCD Model, the modeled potential onshore impacts, are compared with BOEMRE significance levels. If the significance levels are exceeded in an attainment area, an area that meets the NAAQS, the operator would be required to apply best available control technology to the emissions source. If the affected area is classified as nonattainment, further emission reductions or offsets may be required. Projected contributions to onshore pollutant concentrations are also subject to the same limits as USEPA applies to the onshore areas under their PSD program.

Flaring/Venting

Flaring is the controlled burning of natural gas, and venting is releasing gas directly into the atmosphere without burning. Flaring/venting may be necessary to remove potentially damaging completion fluids from the wellbore and to provide sufficient reservoir data for the operator to evaluate reservoir development options during unloading/testing operations and/or in emergency situations. The BOEMRE regulates flaring/venting to minimize the loss of revenue producing natural gas resources. The BOEMRE regulations (30 CFR 250.1160) allow, without prior BOEMRE approval, flaring or venting of natural gas on a limited basis under certain specified conditions. Regulations permit more extensive flaring/venting with prior approval from BOEMRE. Records must always be prepared by the operator for all flaring/venting, and justification must be provided for flaring/venting not expressly authorized by BOEMRE regulations.

Hydrogen Sulfide Contingency Plans

The operator of a lease must request a BOEMRE area classification for the presence of hydrogen sulfide (H_2S) gas. The BOEMRE classifies areas for proposed operations as (1) H_2S absent, (2) H_2S present, or (3) H_2S unknown.

All OCS operators concerned with the production of sour (contains H_2S) hydrocarbons that could result in atmospheric H_2S concentrations above 20 parts per million are required to file an H_2S contingency plan with BOEMRE. This plan must include the 30 CFR 250 requirements that are intended to ensure workers safety at the production facility and provide contingencies for; simultaneous drilling, well-completion, well-workovers, and production operations. The NTL 2009-G31, "Hydrogen Sulfide (H_2S) Requirements," provides clarification, guidance, and information regarding BOEMRE's H_2S regulations at 30 CFR 250.

Archaeological Resources Regulation

Bottom-disturbing operations such as well placement, anchoring, and pipelaying activities can lead to damage to any resources that reside on the seabed, particularly archaeological resources such as historic shipwrecks. The archaeological resources regulation at 30 CFR 250.194 grants authority in certain cases to each BOEMRE Regional Director to require that archaeological reports be submitted with the EP, DOCD, or DPP where deemed necessary. The technical requirements of the archaeological resource reports are detailed in NTL 2005-G07, "Archaeological Resource Surveys and Reports." If the evidence from the operator's geophysical survey and/or archaeological report suggests that an archaeological resource may be present, the lessee must either locate the site of any operation so as not to adversely affect the area where the archaeological resource may be, demonstrate that an archaeological resource does not exist, or demonstrate that archaeological resources will not be adversely affected by operations. If the lessee discovers any archaeological resource while conducting approved operations, operations must be immediately stopped and the discovery reported to the BOEMRE Regional Supervisor, Office of Leasing and Environment, within 48 hours of its discovery.

High-resolution surveys provide an effective tool that analysts use to identify and help protect archaeological resources; however, such survey coverage is often not available for all areas of the GOM, particularly in deeper water where oil and gas activities are increasing and where more shipwrecks are being identified. As part of the environmental reviews conducted for postlease activities, available information will be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if mitigation is warranted.

Coastal Zone Management Consistency Review and Appeals for Plans

The Coastal Zone Management Act (CZMA) places requirements on any applicant for an OCS plan that describes in detail Federal license or permit activities affecting any coastal use or resource, in or outside of a State's coastal zone. The applicant must provide in the OCS plan submitted to BOEMRE a certification and necessary data and information for the State to determine that the proposed activities comply with the enforceable policies of the States' approved coastal management program, and that such activities will be consistent to the maximum extent practicable (16 U.S.C. 1456(c)(3)(A) and 15 CFR 930.76).

Except as provided in 15 CFR 930.60(a), State agency review of the consistency certification begins when the State receives the certification and information required pursuant to 15 CFR 930.76(a) and (b). Only missing information can be used to delay the commencement of State agency review, and a request for information and data that are not required by 15 CFR 930.76 will not extend the date of commencement of review (15 CFR 930.58). Under the CZMA, each State with an approved CMP may require information that is different from that specifically outlined in these regulations. All of the Gulf States have approved CMP's. Requirements for the CZM consistency information for Texas, Louisiana, Mississippi, Alabama, and Florida are found at 30 CFR 250.226 and 250.260, and are given in NTL's 2006-G21, "Regional and Subregional Oil Spill Response Plans"; 2007-G20, "Coastal Zone Management Program Requirements for OCS Right-of-way Pipeline Applications;" 2008-G04, "Information Requirements for Exploration Plans and Development Operations Coordination Documents"; and 2009-G27, "Submitting Exploration Plans and Development Coordination Documents." In accordance

with the requirements of 15 CFR 930.76, BOEMRE's Gulf of Mexico OCS Region sends copies of an OCS plan, including the consistency certification and other data and necessary information, to the designated State CMP agency by receipted mail or other approved communication. If no State-agency objection is submitted by the end of the consistency review period, BOEMRE shall presume consistency concurrence by the State (15 CFR 930.78 (b)). The BOEMRE can require modification of a plan if the operator has agreed to certain requirements requested by the State.

If BOEMRE receives a written consistency objection from the State, BOEMRE will not approve any activity described in the OCS plan unless (1) the operator amends the OCS plan to accommodate the objection, concurrence is subsequently received or conclusively presumed; (2) upon appeal, the Secretary of Commerce, in accordance with 15 CFR 930 Subpart H, finds that the OCS plan is consistent with the objectives or purposes of the CZMA or is necessary in the interest of national security; or (3) the original objection is declared invalid by the courts.

Best Available and Safest Technologies

To assure that oil and gas exploration, development, and production activities on the OCS are conducted in a safe and pollution-free manner, 43 U.S.C. 1347(b) of the OCSLA, as amended, requires that all OCS technologies and operations use the best available and safest technology (BAST) whenever practical. The Director may require additional BAST measures to protect safety, health, and the environment, if it is economically feasible and the benefits outweigh the costs. Conformance to the standards, codes, and practices referenced in or required under the authority of 30 CFR 250 is considered the application of BAST. These standards, codes, and practices include requirements for state-of-the-art drilling technology, production safety systems, oil and gas well completions, oil-spill response plans, pollution-control equipment, and specifications for platform/structure designs. The BOEMRE conducts periodic offshore inspections, and continuously and systematically reviews OCS technologies to ensure that the best available and safest technologies are applied to OCS operations. The BAST is not required when BOEMRE determines that the incremental benefits are clearly insufficient to justify increased costs; however, it is the responsibility of an operator of an existing operation to demonstrate why application of a new technology would not be feasible. This requirement is applicable to equipment and procedures that, if failed, would have a significant effect on safety, health, or the environment, unless benefits clearly do not justify the cost (30 CFR 250.107(c) and (d)).

The BAST concept is addressed in the BOEMRE, Gulf of Mexico OCS Region by a continuous effort to locate and evaluate the latest technologies and to report on these advances at periodic Regional Operations Technology Assessment Committee (ROTAC) meetings. A part of the BOEMRE staff has an ongoing function to evaluate various vendors and industry representatives' innovations and improvements in techniques, tools, equipment, procedures, and technologies applicable to oil and gas operations (drilling, producing, completion, and workover operations). This information is provided to BOEMRE district personnel at ROTAC meetings. The requirement for the use of BAST has been, for the most part, an evolutionary process whereby advances in equipment, technologies, and procedures have been integrated into OCS operations over a period of time. Awareness by both BOEMRE inspectors and the OCS operators of the most advanced equipment and technologies has resulted in the incorporation of these advances into day-to-day operations. An example of such an equipment change that evolved over a period of time would be the upgrading of diverter systems on drilling rigs from the smaller diameter systems of the past to the large-diameter, high-capacity systems found on drilling rigs operating on the OCS today.

Production Facilities

The BOEMRE's regulations governing oil and gas production safety systems are found in 30 CFR 250 Subpart H. Production safety equipment used on the OCS must be designed, installed, used, maintained, and tested in a manner to assure the safety and protection of the human, marine, and coastal environments. All tubing installations open to hydrocarbon-bearing zones below the surface must be equipped with safety devices that will shut off the flow from the well in the event of an emergency, unless the well is incapable of flowing. Surface- and subsurface-controlled safety valves and locks must conform to the requirements of 30 CFR 250.801. All surface production facilities, including separator and treatment tanks, compressors, headers, and flowlines must be designed, installed, and maintained in a

manner that provides for efficiency, safety of operations, and protection of the environment. Production facilities also have stringent requirements concerning electrical systems, flowlines, engines, and firefighting systems. The safety-system devices are tested by the lessee at specified intervals and must be in accordance with API RP 14 C Appendix D and other measures.

Personnel Training and Education

An important factor in ensuring that offshore oil and gas operations are carried out in a manner that emphasizes operational safety and minimizes the risk of environmental damage is the proper training of personnel. Under 30 CFR 250.Subpart O, BOEMRE has outlined well control and production safety training program requirements for lessees operating on the OCS. The goal of the regulation (30 CFR 250.1501) is safe and clean OCS operations. Lessees must ensure that their employees and contract personnel engaged in well control or production safety operations understand and can properly perform their duties. To accomplish this, the lessee must establish and implement a training program so that all of their employees are trained to competently perform their assigned well control and production safety duties. The lessee must also verify that their employees understand and can perform the assigned duties.

The mandatory Drilling Well-Control Training Program was instituted by this Agency in 1979. In 1983, the mandatory Safety Device Training Program was established to ensure that personnel involved in installing, inspecting, testing, and maintaining safety devices are qualified. As a preventive measure, all offshore personnel must be trained to operate oil-spill cleanup equipment, or the lessee must retain a trained contractor(s) to operate the equipment for them. In addition, BOEMRE offers numerous technical seminars to ensure that personnel are capable of performing their duties and are incorporating the most up-to-date safety procedures and technology in the petroleum industry. In 1994, the Office of Safety Management created this Agency's Offshore Training Institute to develop and implement an inspector training program. The Institute introduced state-of-the-art multimedia training to the inspector work force and has produced a series of interactive computer training modules.

Structure Removal and Site Clearance

During exploration, development, and production operations, temporary and permanent equipment and structures are often required to be embedded into or placed onto the seafloor around activity areas. In compliance with Section 22 of BOEMRE's Oil and Gas Lease Form (MMS-2005) and OCSLA regulations (30 CFR 250.1710—*Wellheads/Casings* and 30 CFR 250.1725—*Platforms and Other Facilities*), operators need to remove seafloor obstructions from their leases within 1 year of lease termination or after a structure has been deemed obsolete or unusable. These regulations also require the operator to sever bottom-founded objects and their related components at least 5 m (15 ft) below the mudline (30 CFR 250.1716(a)—*Wellheads/Casings* and 30 CFR 250.1728(a)—*Platforms and Other Facilities*). The severance operations are generally categorized as explosive or nonexplosive.

Chapter 1.5 of the Multisale EIS describes regulations, reporting guidelines, and specific mitigation measures developed through consultation, pursuant to Section 7 of the ESA and the MMPA, concerning potential impacts on endangered and threatened species associated with explosive severance activities conducted during the structure-removal operations. All of the current terms and conditions of structure and well removal activities are outlined in NTL 2010-G05, "Decommissioning Guidance for Wells and Platforms," which became effective on October 15, 2010.

Marine Protected Species NTL's

Three NTL's that were issued in 2007 advise operators in measures designed to reduce impacts to Marine Protected Species: NTL 2007-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program"; NTL 2007-G03, "Marine Trash and Debris Awareness and Elimination"; and NTL 2007-G04, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting." The provisions outlined in these NTL's apply to all existing and future oil and gas operations in the Gulf of Mexico OCS.

The NTL 2007-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," provides guidance to protect marine mammals and sea turtles during seismic operations. This NTL clarifies how operators should implement seismic survey mitigation measures,

including ramp-up procedures, the use of a minimum sound source, airgun testing. and protected species observation and reporting. The measures contained in this NTL apply to all on-lease surveys conducted under 30 CFR 250 and to all off-lease surveys conducted under 30 CFR 251.

The NTL 2007-G03, "Marine Trash and Debris Awareness and Elimination," provides guidance to prevent intentional and/or accidental introduction of debris into the marine environment. Operators are prohibited from deliberately discharging containers and other similar materials (i.e., trash and debris) into the marine environment (30 CFR 250.300(a) and (b)(6)) and are required to make durable identification markings on equipment, tools, containers (especially drums), and other material (30 CFR 250.300(c)). The intentional jettisoning of trash has been the subject of strict laws such as the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V and the Marine Plastic Pollution Research and Control Act, and regulations imposed by various agencies including USCG and USEPA. These USCG and USEPA regulations require that operators become more proactive in avoiding the accidental loss of solid-waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. The NTL 2007-G03 states that marine debris placards must be posted in prominent places on all fixed and floating production facilities that have sleeping or food preparation capabilities and on mobile drilling units. Operators must also ensure that all of their offshore employees and those contractors actively engaged in their offshore operations complete annual training that includes (1) viewing a training video or slide show (specific options are outlined in the NTL) and (2) receiving an explanation from the lessee company's management that emphasizes their commitment to the NTL's provisions. An annual report that describes the marine trash and debris awareness training process and certifies that the training process has been followed for the previous calendar year is to be provided to BOEMRE by January 31 of each year.

The NTL 2007-G04, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting," explains how operators must implement measures to minimize the risk of vessel strikes to protected species and must report observations of injured or dead protected species. Vessel operators and crews must maintain a vigilant watch for marine protected species and slow down or stop their vessel to avoid striking protected species. Crews must report sightings of any injured or dead protected species (marine mammals and sea turtles) immediately, regardless of whether the injury or death is caused by their vessel, to the Marine Mammal and Sea Turtle Stranding Hotline or the Marine Mammal Stranding Network. In addition, if it was the operator's vessel that collided with a protected species, BOEMRE must be notified within 24 hours of the strike.

Rigs-to-Reefs

Rigs-to-Reefs (RTR) is a term for converting obsolete, nonproductive offshore oil and gas platforms to designated artificial reefs (Dauterive, 2000). Disposal of obsolete offshore oil and gas platforms is not only a financial liability for the oil and gas industry but it can be a loss of productive marine habitat. The use of obsolete oil and gas platforms for reefs has proven to be highly successful. Their availability, design profile, durability, and stability provide a number of advantages over the use of traditional artificial reef materials. To capture this valuable fish habitat, the States of Louisiana, Texas, and Mississippi, in 1986, 1989, and 1999, respectively, passed enabling legislation and signed into law a RTR program to coincide with their respective States' Artificial Reef Plan. Alabama and Florida have no RTR legislation. The State laws set up a mechanism to transfer ownership and liability of the platform from oil and gas companies to the State when the platform ceases production and the lease is terminated. The company (donor) saves money by donating a platform to the State (recipient) for a reef rather than scrapping the platform onshore. The industry then donates 50 percent of the savings to the State, which is put toward the State's artificial reef program. Since the inception of the RTR program, more than 300 retired platforms have been donated and used as reefs in the GOM.

1.6. OTHER OCS-RELATED ACTIVITIES

The BOEMRE has programs and activities that are OCS related but not specific to the oil and gas leasing process or to the management of exploration, development, and production activities. These programs include both environmental and technical studies, and cooperative agreements with other

Federal and State agencies for NEPA work, joint jurisdiction over cooperative efforts, inspection activities, and regulatory enforcement. The BOEMRE also participates in industry research efforts and forums.

Environmental Studies Program

The Environmental Studies Program (ESP) was established in 1973 in accordance with Section 20 of the OCSLA. The goals of the ESP are to obtain environmental and socioeconomic information that can be used to assess the potential and real effects of the GOM OCS natural gas and oil program. As a part of the ESP, the Gulf of Mexico OCS Region has funded more than 350 completed or ongoing environmental studies. The types of studies funded include

- literature reviews and baseline studies of the physical, chemical, and biological environment of the shelf;
- literature review and studies of the physical, chemical, and biological environment of deep water (>300 m or 1,000 ft);
- studies of the socioeconomic impacts along the Gulf Coast; and
- studies of the effects of oil and gas activities on the marine environment.

A list of the Gulf of Mexico OCS Region's studies published from 2006 to the present is presented in **Appendix C**. Studies completed since 1974 are available on the BOEMRE, Gulf of Mexico OCS Region's Internet website under "Environmental Program." The BOEMRE's Environmental Studies Program Information System (ESPIS) provides immediate access to all completed BOEMRE studies. The ESPIS is a searchable, web-based, full-text retrieval system allowing users to view online or to download the complete text of any completed ESP report. A complete list of all ongoing Gulf of Mexico OCS Region studies is available on the BOEMRE Internet website. Each listing not only describes the research being conducted but also shows the institution performing the work, the cost of the effort, timeframe, and any associated publications, presentations, or affiliated websites.

The ESP funds studies to obtain information needed for NEPA assessment and the management of environmental and socioeconomic impacts on the human, marine, and coastal environments that may be affected by OCS oil and gas development. The ESP studies were used by BOEMRE's Gulf of Mexico OCS Region analysts to prepare this document. While not all of the Gulf of Mexico OCS Region's studies are specifically referenced in this document, they were used by analysts as input into their analyses. The information in ESP studies is also used by decisionmakers to manage and regulate exploration, development, and production activities on the OCS.

Technology Assessment & Research Program

The Technology Assessment & Research (TA&R) Program supports research associated with operational safety and pollution prevention as well as oil-spill response and cleanup capabilities. The TA&R Program is comprised of two functional research activities: (1) operational safety and engineering research (topics such as air quality, decommissioning, and mooring and anchoring); and (2) oil-spill research (topics such as behavior of oil, chemical treating agents, and in situ burning of oil). The TA&R Program has four primary objectives.

- Technical Support—Providing engineering support in evaluating industry operational proposals and related technical issues and in ensuring that these proposals comply with applicable regulations, rules, and operational guidelines and standards.
- Technology Assessment—Investigating and assessing industry applications of technological innovations and ensuring that governing BOEMRE regulations, rules, and operational guidelines ensure the use of BAST (**Chapter 1.5**, *New and Unusual Technology*).

- Research Catalyst—Promoting and participating in industry research initiatives in the fields of operational safety, engineering research, and oil-spill response and cleanup research.
- International Regulations—Supporting international cooperative efforts for research and development initiatives to enhance the safety of offshore oil and natural gas activities and the development of appropriate regulatory program elements worldwide.

Interagency Agreements

Memorandum of Understanding under NEPA

Section 1500.5(b) of the CEQ implementing regulations (40 CFR 1500.5(b)) encourages agency cooperation early in the NEPA process. A Federal agency can be a lead, joint lead, or cooperating agency. A lead agency manages the NEPA process and is responsible for the preparation of an EIS; a joint lead Agency shares these responsibilities; and a cooperating agency that has jurisdiction by law and has special expertise with respect to any environmental issue shall participate in the NEPA process upon the request of the lead agency.

When an agency becomes a Cooperating Agency, the cooperating and lead agencies usually enter into an MOU, previously called a Cooperating Agency Agreement. The Agreement details the responsibilities of each participating agency. The BOEMRE, as lead agency, has requested other Federal agencies to become cooperating agencies while other agencies have requested BOEMRE to become a cooperating agency (e.g., the Ocean Express Pipeline project). Some projects, such as major gas pipelines across Federal waters and projects under the Deepwater Port Act of 1974, can require cooperative efforts by multiple Federal and State agencies.

The NOI included an invitation to other Federal agencies and State, tribal, and local governments to consider becoming cooperating agencies in the preparation of this Supplemental EIS.

Memorandum of Understanding and Memoranda of Agreements between MMS (BOEMRE) and USCG

Since BOEMRE and USCG have closely related jurisdiction over different aspects of safety and operations on the OCS, the agencies have established a formal MOU that delineates lead responsibilities for managing OCS activities in accordance with the OCSLA, as amended, and OPA. The latest MOU, dated September 30, 2004, supersedes the August 1989 and December 1998 versions of the interagency agreement. The MOU is designed to minimize duplication and promote consistent regulation of facilities under the jurisdiction of both agencies. A Memorandum of Agreement (MOA), OCS No. 1—Agency Responsibilities, between BOEMRE and USCG, dated September 30, 2004, further clarifies the technical and process section of the BOEMRE/USCG MOU. The MOA requires the participating agencies to review their internal procedures and, where appropriate, revise them to accommodate the provisions of the September 2004 MOA. To facilitate coordination with USCG, BOEMRE has established a full-time position within the Office of Offshore Regulatory Programs to provide liaison between the agencies.

Generally, the MOU identifies BOEMRE as the lead agency for matters concerning the equipment and operations directly involved in the production of oil and gas. These include, among others, design and operation of risers, permanent mooring foundations of the facility, drilling and well production and services, inspection and testing of all drilling-related equipment, and platform decommissioning. Issues regarding certain aspects of safe operation of the facility, its systems, and equipment generally fall under the jurisdiction of USCG. These include, among others, design of vessels, their sea-keeping characteristics, propulsion and dynamic positioning systems, supply and lightering procedures and equipment, utility systems, safety equipment and procedures, and pollution prevention and response procedures. In 2002, this Agency was authorized to inspect USCG-related safety items on fixed facilities on the OCS.

Generally, the MOA identifies agency responsibilities (i.e., agency representatives for the purpose of keeping each other informed of issues, relevant applications, routine policy determinations and to coordinate joint activities), civil penalties (i.e., USCG refers civil penalty cases to BOEMRE), OSFR (i.e.,

BOEMRE determines and provides OSFR-related information to USCG upon request), oil-spill preparedness and response planning (i.e., BOEMRE requires responsible parties to maintain approved oil-spill-response plans consistent with Area Contingency Plans and the National Contingency Plan), oil-spill response (i.e., reporting all spills to the National Response Center and direct measures to abate sources of pollution from an OCS facility), accident investigations (i.e., BOEMRE and USCG responsible for investigating and preparing report of fires, spillage, injury, fatality and blowouts and collisions and allisions), and offshore facility system/subsystem responsibility matrix (identifies lead agency responsible for MODU, fixed, and floating systems and subsystems, and coordinates with other agencies as appropriate).

On April 18, 2005, this Agency and USCG met to identify MOA's that needed to be developed and to prioritize work. The following subject areas were selected: (a) civil penalties; (b) incident investigations; (c) offshore security; (d) oil-spill planning, preparedness, and response; (e) deepwater ports; (f) digital databases; (g) MODU's; (h) fixed platforms; (i) floating platforms; (j) floating, production, storage, and offloading units (FPSO's); and (k) incident reporting. Joint agency teams have been established to develop the MOA's for the first five subject areas. In addition, an MOA is also being pursued to address renewable energy and alternate use of the OCS. The Civil Penalties MOA-OCS-02 was approved on September 12, 2006. The Oil Discharge Planning, Preparedness, and Response MOA-OCS-03 became effective on May 23, 2009, and the Incident Investigation MOA-OCS-05 became effective on March 27, 2009.

CHAPTER 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

This Supplemental EIS addresses one areawide oil and gas lease sale in the CPA of the Gulf of Mexico OCS (**Figure 1-1**), as scheduled in the current *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012* (5-Year Program; USDOI, MMS, 2007a). The proposed action (proposed lease sale) includes regulations in place at the time a Record of Decision is made for this Supplemental EIS and lease stipulations. As a result of the DWH event, there are multiple groups and bodies that have been impaneled to offer recommendations on how OCS regulations may be changed (**Table 2-1**). Some of these inquiries have concluded their business and some have not. On October 14, 2010, the new interim final rules for OCS operations were published in the *Federal Register* (2010b). On October 15, 2010, the final rule for OCS safety and environmental management systems was published in the *Federal Register* (2010a). **Chapter 1.3.1** explains these regulatory changes, which are part of the proposed action and all alternatives.

2.1. SUPPLEMENTAL EIS NEPA ANALYSIS

This Supplemental EIS tiers from the Multisale EIS and the 2009-2012 Supplemental EIS. Its purpose is to determine if new information is substantial enough to alter the conclusions stated in the Multisale EIS and the 2009-2012 Supplemental EIS and, if so, to disclose those changes. This includes all new information and not just that acquired since the DWH event. This Agency utilized the best information available derived from ongoing and past research to determine if the baseline condition for resources had changed since the Multisale EIS and the 2009-2012 Supplemental EIS due to the DWH event or any other factor. This Supplemental EIS presents an impartial analysis of new information that is available through sources open to Agency experts.

This Supplemental EIS was prepared in consideration of the potential changes to the baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of the DWH event. These environmental resources include sensitive coastal environments and offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS also considered the DWH event in the analysis of the potential alternatives of the proposed action.

It must be understood that this Supplemental EIS analyzes the proposed action and alternatives for the proposed CPA lease sale. This is not an EIS on the DWH event, although information on this event will be analyzed as it applies to resources in the CPA.

In regards to the DWH event, on March 8, 2011, BOEMRE was invited to be a Cooperating Agency by NOAA in the preparation of a Programmatic EIS to support development of a suite of preferred restoration alternatives to compensate for natural resource injuries resulting from the DWH event and the resulting oil spill. The Programmatic EIS is a separate action under the Natural Resource Damage Assessment (NRDA) process that will aid the Trustees in the effective planning for use of DWH restoration funds. The restoration planning process will be used to solicit public and agency comment to aid in restoration planning. The invitation was due to BOEMRE's unique expertise or jurisdiction over activities and/or resources that may be impacted by restoration activities undertaken under the Programmatic EIS. The Programmatic EIS is a separate action that is not related to this Supplemental EIS.

2.2. ALTERNATIVES, MITIGATING MEASURES, AND ISSUES

2.2.1. Alternatives

2.2.1.1. Alternatives for Proposed Central Planning Area Lease Sale 216/222

The following alternatives were included for analysis in the Multisale EIS and the 2009-2012 Supplemental EIS and are described in detail in **Chapter 2.4**. As explained in **Chapter 2.2.1.3.**, the Use of a Nomination and Tract Selection Leasing System Alternative was not included for analysis in this Supplemental EIS because of an ongoing BOEMRE study on alternative approaches to leasing.

Alternative A—The Proposed Action: This alternative would offer for lease all unleased blocks within the CPA for oil and gas operations (**Figure 2-1**), except for the following:

(1) blocks directly south of Florida and within 100 mi of the Florida coast (north of the easternmost portion of the proposed CPA lease sale area as shown on **Figure 1-1**); and

(2) blocks that are beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap.

The CPA sale area encompasses about 63 million ac of the CPA's 66.3 million ac. Approximately 37.1 million ac (59%) of the CPA sale area is currently unleased. The estimated amount of resources projected to be developed as a result of the proposed CPA lease sale is 0.801-1.624 BBO and 3.332-6.560 Tcf of gas.

Alternative B—The Proposed Action Excluding the Unleased Blocks Near Biologically Sensitive Topographic Features: This alternative would offer for lease all unleased blocks in the CPA, as described for the proposed action (Alternative A), with the exception of any unleased blocks subject to the Topographic Features Stipulation.

Alternative C—The Proposed Action Excluding the Unleased Blocks within 15 Miles of the Baldwin County, Alabama, Coast: This alternative would offer for lease all unleased blocks in the CPA, as described for the proposed action (Alternative A), with the exception of any unleased blocks within 15 mi (24 km) of the Baldwin County, Alabama, coast.

Alternative D—No Action: This alternative is the cancellation of the proposed CPA lease sale. The opportunity for development of the estimated 0.801-1.624 BBO and 3.332-6.560 Tcf of gas that could have resulted from the proposed CPA lease sale would be precluded or postponed. Any potential environmental impacts resulting from the proposed lease sale would not occur or would be postponed. This is also analyzed in the EIS for the 5-Year Program on a nationwide programmatic level.

2.2.1.2. Alternatives Considered but Not Analyzed

Alternatives to Areawide Leasing

The Multisale EIS forecasted a future analysis for Use of a Nomination and Tract Selection Leasing System Alternative for both a WPA and CPA proposed lease sale. Since the publication of the Multisale EIS, this Agency has contracted a study of leasing policy alternatives that may serve to further the many goals of the OCSLA.

The study began in October 2007 and at that time was expected to take about 18 months to complete. This Agency received a final version of the original study in the third quarter of FY 2009. The study evaluated different leasing options, some pertaining to the alternative size of areas offered for leasing and some pertaining to alternative lease terms and conditions. Options for alternative sizes included areawide annual, areawide every other year, or 5 percent of areawide as a proxy for nomination scale. Options for alternative lease terms and conditions included different royalty rates, minimum bid or rental amounts, profit shares, work commitments, multi-round bidding, and shorter primary terms. No combination of options was provisionally found superior to the current system on all performance measures. The performance measures against which the alternatives were evaluated included expeditious and orderly development of resources, fair return for leased resources, promotion of competition, equitable sharing of the costs and benefits of offshore leasing, facilitation of regional planning, minimizing environmental risks, and maximizing social value.

In January 2010, this Agency modified the original contract to have an additional scenario (growth in resource size from the most current estimates) run through the original contractor's model. Then, after the DWH event, BOEMRE did a second contract modification to address scenarios involving a drilling pause and a delay in future lease sales such as is occurring now. When this additional work is delivered, BOEMRE will reconsider alternative leasing scenarios. Informed by this study and recent events, future leasing decisions could result in fewer sales, smaller sale sizes, or higher fees, any of which would more simply and directly serve many of the same purposes as tract nomination sales. The recommendations from multiple Secretarial and Presidential inquiries (**Table 2-1**) are likely to include stricter drilling and

safety requirements that would need to be considered in conjunction with leasing system alternatives. It is possible that future leasing decisions could result directly or indirectly in fewer blocks leased per sale or fewer sales held per year, leading ultimately to fewer blocks drilled and developed.

Pending completion of the revised scope of work for the alternative leasing system analysis within the wider context of possible or likely regulatory changes, BOEMRE believes that it is not appropriate to include the Use of a Nomination and Tract Selection Leasing System Alternative in this Supplemental EIS.

2.2.2. Mitigating Measures

The NEPA process is intended to help public officials make decisions that are based on their understanding of environmental consequences and to take actions that protect, restore, and enhance the environment. Agencies are required to identify and include in the proposed action all relevant and reasonable mitigation measures that could improve the action. In 1978, Section 1508.20 of CEQ defined mitigation as

- Avoidance—Avoiding an impact altogether by not taking a certain action or part of an action.
- Minimization—Minimizing impacts by limiting the intensity or magnitude of the action and its implementation.
- Restoration—Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Maintenance—Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensation—Compensating for the impact by replacing or providing substitute resources or environments.

2.2.2.1. Proposed Mitigating Measures Analyzed

The potential mitigating measures included for analysis in this Supplemental EIS were developed as the result of scoping efforts over a number of years for the continuing OCS Program in the Gulf of Mexico. Eight lease stipulations (described in **Chapter 2.3.1.3**) are proposed for the CPA Lease Sale 216/222—the Topographic Features Stipulation; the Live Bottom Stipulation; the Military Areas Stipulation; the Evacuation Stipulation; the Coordination Stipulation; the Blocks South of Baldwin County, Alabama, Stipulation; the Protected Species Stipulation; and the Law of the Sea Convention Royalty Payment Stipulation. The Law of the Sea Convention Royalty Payment Stipulation is applicable to the CPA lease sale even though it is not an environmental or military stipulation.

These measures will be considered for adoption by the ASLM, under authority delegated by the Secretary of the Interior. The analysis of any stipulations as part of Alternative A does not ensure that the ASLM will make a decision to apply the stipulations to leases that may result from any proposed lease sale nor does it preclude minor modifications in wording during subsequent steps in the prelease process if comments indicate changes are necessary or if conditions change.

Any stipulations or mitigation requirements to be included in a lease sale will be described in the ROD for that lease sale. Mitigating measures in the form of lease stipulations are added to the lease terms and are therefore enforceable as part of the lease. In addition, each exploration and development plan, as well as any pipeline applications that may result from the lease sale, will undergo a NEPA review, and additional project-specific mitigations are routinely applied as conditions of plan approval. The BOEMRE has the authority to monitor and enforce these conditions, and under 30 CFR 250 Subpart N, may seek remedies and penalties from any operator that fails to comply with the conditions of permit approvals, including stipulations and other mitigating measures.

2.2.2.2. Existing Mitigating Measures

This section discusses only mitigating measures that would be applied by BOEMRE. Mitigating measures have been proposed, identified, evaluated, or developed through previous BOEMRE lease sale NEPA review and analysis. Many of these mitigating measures have been adopted and incorporated into regulations and/or guidelines governing OCS exploration, development, and production activities. All plans for OCS activities (e.g., exploration and development plans, pipeline applications, and structure-removal applications) go through rigorous BOEMRE review and approval to ensure compliance with established laws and regulations. Existing mitigating measures must be incorporated and documented in plans submitted to BOEMRE. Operational compliance of these mitigating measures is enforced through BOEMRE's onsite inspection program.

Mitigating measures that are a standard part of BOEMRE's program ensure that the operations are always conducted in an environmentally sound manner (with an emphasis on minimizing any adverse impact of routine operations on the environment). For example, mitigating measures ensure site clearance procedures that eliminate potential snags to commercial fishing nets and that, as appropriate, may require surveys to detect and avoid archaeological sites and biologically sensitive areas such as pinnacles, topographic features, and chemosynthetic communities.

Some BOEMRE-identified mitigating measures are incorporated into OCS operations through cooperative agreements or efforts with industry and various State and Federal agencies. These mitigating measures include NMFS's Observer Program to protect marine mammals and sea turtles during explosive removals, development of methods of pipeline landfall to eliminate impacts to beaches or wetlands, and beach cleanup events.

Site-specific mitigating measures are also applied by BOEMRE during plan and permit reviews. The BOEMRE realized that many of these site-specific mitigations were recurring and developed a list of "standard" mitigations. There are currently over 120 standard mitigations. The wording of a standard mitigation is developed by BOEMRE in advance and may be applied whenever conditions warrant. Standard mitigation text is revised as often as is necessary (e.g., to reflect changes in regulatory citations, agency/personnel contact numbers, and internal policy). Site-specific mitigation "categories" include the following: air quality; archaeological resources; artificial reef material; chemosynthetic communities; Flower Garden Banks; topographic features; hard bottoms/pinnacles; military warning areas and Eglin Water Test Areas (EWTA's); Naval mine warfare areas; hydrogen sulfide; drilling hazards; remotely operated vehicle surveys; geophysical survey reviews; and general safety concerns. Site-specific mitigation "types" include the following: advisories; conditions of approval; hazard survey reviews; inspection requirements; notifications; post-approval submittals; reminders; and safety precautions. In addition to standard mitigations, BOEMRE may also apply nonrecurring mitigating measures that are developed on a case-by-case basis.

The BOEMRE is continually revising applicable mitigations to allow the Gulf of Mexico Region to more easily and routinely track mitigation compliance and effectiveness. A primary focus of this effort is requiring post-approval submittal of information within a specified timeframe after a triggering event that is tracked by BOEMRE (e.g., end of operations reports for plans, construction reports for pipelines, and removal reports for structure removals).

2.2.3. Issues

Issues are defined by CEQ to represent those principal "effects" that an EIS should evaluate in-depth. Scoping identifies specific environmental resources and/or activities rather than "causes" as significant issues (CEQ Guidance on Scoping, April 30, 1981). The analysis in the EIS can then show the degree of change from present conditions for each issue due to the relevant actions related to the proposed action.

Selection of environmental and socioeconomic issues to be analyzed was based on the following criteria:

- issue is identified in CEQ regulations as subject to evaluation;
- the relevant resource/activity was identified through agency expertise, through the scoping process, or from comments on past EIS's;

- the resource/activity may be vulnerable to one or more of the impact-producing factors associated with the OCS Program; a reasonable probability of an interaction between the resource/activity and impact-producing factor should exist; or

- information that indicates a need to evaluate the potential impacts to a resource/activity has become available.

2.2.3.1. Issues to be Analyzed

Like the Multisale EIS and the 2009-2012 Supplemental EIS, this Supplemental EIS addresses issues related to potential impact-producing factors and the environmental and economic resources and activities that could be affected by OCS exploration, development, production, and transportation activities. A reevaluation of affected environmental resources based on the effects of the DWH event is warranted. The baseline condition of some resources has been changed, some to a greater degree than others, and preparation of this Supplemental EIS was judged by BOEMRE to be appropriate for this evaluation of the one remaining CPA lease sale in the 5-Year Program

2.2.3.2. Issues Considered but Not Analyzed

As previously noted, the CEQ regulations for implementing NEPA instruct agencies to adopt an early process (termed "scoping") for determining the scope of issues to be addressed and for identifying significant issues related to a proposed action. As part of this scoping process, agencies shall identify and eliminate from detailed study the issues that are not significant to the proposed action or have been covered by prior environmental review.

Through our scoping efforts, numerous issues and topics were identified for consideration in the Multisale EIS, the 2009-2012 Supplemental EIS, and this Supplemental EIS. After careful evaluation and study, the following categories were considered not to be significant issues related to the proposed action or that have been covered by prior environmental review.

Program and Policy Issues

Comments and concerns that relate to program and policy are issues under the direction of the Department of the Interior and/or BOEMRE, and their guiding regulations, statutes, and laws. The comments and concerns related to program and policy issues are not considered to be specifically related to the proposed action. Such comments are forwarded to the appropriate program offices for their consideration. Programmatic issues including expansion of the sale area, administrative boundaries, and royalty relief have been considered in the preparation of the EIS for the 5-Year Program.

Revenue Sharing

A number of comments were received on previous EIS's from State and local governments, interest groups, and the general public stating that locally affected communities should receive an increased share of revenues generated by the OCS oil and gas leasing program. This increased revenue would act as mitigation of OCS-related impacts to coastal communities including impacts to Louisiana Highway 1 (LA Hwy 1) and Lafourche Parish, Louisiana, from OCS-related activity at Port Fourchon. Comments and concerns that relate to the use and distribution of revenues are issues under the direction of the U.S. Congress or the Department of the Interior, and their guiding regulations, statutes, and laws.

The BOEMRE distributes revenues collected from Federal mineral leases to special-purpose funds administered by Federal agencies; to States; and to the General Fund of the U.S. Department of the Treasury. Legislation and regulations provide formulas for the disbursement of these revenues. The distribution of revenues is discussed in Chapter 3.3.5.2 of the Multisale EIS.

With the enactment of GOMESA, the Gulf producing States (i.e., Texas, Louisiana, Mississippi, and Alabama) and their coastal political subdivisions (CPS's) were granted an increased share of offshore oil and gas revenue. Beginning in FY 2007, and thereafter, Gulf producing States and their CPS's received 37.5 percent of the qualified OCS revenue from new leases issued in the 181 Area in the EPA and the 181 South Area. Beginning in FY 2016, and thereafter, Gulf producing States and their CPS's will

receive 37.5 percent and the Land and Water Conservation Fund will receive 12.5 percent of qualified OCS revenue from new leases in the existing areas available for leasing, subject to a $500 million cap. The remaining 50 percent of qualified OCS revenues and revenues exceeding the $500 million cap will be distributed to the U.S. Treasury.

The socioeconomic benefits and impacts to local communities are analyzed in **Chapter 4** of this Supplemental EIS.

2.3. PROPOSED CENTRAL PLANNING AREA LEASE SALE 216/222

The following four alternatives were included for analysis in the Multisale EIS and 2009-2012 Supplemental EIS. As explained in **Chapter 2.2.3.2**, the Use of a Nomination and Tract Selection Leasing System Alternative was not included for analysis in this Supplemental EIS because of an ongoing BOEMRE study on alternative approaches to leasing.

2.3.1. Alternative A—The Proposed Action

2.3.1.1. Description

Alternative A would offer for lease all unleased blocks within the CPA (4.3 million ac) for oil and gas operations (**Figure 1-1**), except the following:

(1) blocks directly south of Florida and within 100 mi of the Florida coast (north of the easternmost portion of the proposed CPA lease sale area as shown on **Figure 1-1**); and

(2) blocks that are beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap.

The CPA sale area encompasses about 63 million ac of the CPA's 66.3 million ac. Approximately 37.1 million ac (59%) of the CPA sale area is currently unleased. The estimated amount of resources projected to be developed as a result of the proposed CPA lease sale is 0.801-1.624 BBO and 3.332-6.560 Tcf of gas.

The analyses of impacts summarized below and described in detail in **Chapter 4** are based on the development scenario, which is a set of assumptions and estimates on the amounts, locations, and timing for OCS exploration, development, and production operations and facilities, both offshore and onshore. A detailed discussion of the development scenario and major related impact-producing factors is included in **Chapter 3**.

2.3.1.2. Summary of Impacts

Air Quality (Chapter 4.1.1.1)

Emissions of pollutants into the atmosphere from the routine activities associated with the CPA proposed action are projected to have minimal impacts to onshore air quality because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from the coastline. As indicated in the Gulf of Mexico Air Quality Study and other modeling studies, the proposed action would have only a small effect on ozone levels in ozone nonattainment areas and would not interfere with the States' schedule for compliance with the National Ambient Air Quality Standards (NAAQS). Regulations, monitoring, mitigation, and the development of emissions-related technologies would ensure these levels stay within the NAAQS.

Accidental events associated with the CPA proposed action that could impact air quality include spills of oil, natural gas, condensate, and refined hydrocarbons; H_2S release; fire; and NAAQS air pollutants (i.e., SO_x, NO_x, VOC's, CO, PM_{10}, and $PM_{2.5}$). Response activities that could impact air quality include emergency response vehicles, in-situ burning, the use of flares to burn gas and oil, and the use of dispersants applied from aircraft. Measurements taken during an in-situ burning show that a major portion of compounds was consumed in the burn; therefore, pollutant concentrations would be expected

to be within the NAAQS. In a recent analysis of air in coastal communities, low levels of dispersants were identified. These response activities are temporary in nature and occur offshore; therefore, there are little expected impacts from these actions to onshore air quality. Accidents involving high concentrations of H_2S could result in deaths as well as environmental damage. Regulations and NTL's are in place to protect workers from H_2S releases. Other emissions of pollutants into the atmosphere from accidental events as a result of the CPA proposed action are not projected to have significant impacts on onshore air quality because of the prevailing atmospheric conditions, emissions height, emission rates, and the distance of these emissions from the coastline. These emissions are not expected to have concentrations that would change onshore air quality classifications.

Overall, since loss of well-control events and blowouts are rare and are of short duration, potential impacts to air quality are not expected to be significant, except in the rare case of a catastrophic event. The summary of vast amounts of data collected and additional studies will provide more information in the future.

Although BOEMRE regulates the air emissions and air quality in the Gulf of Mexico region, at present, BOEMRE does not have an air quality model for the estimate of air concentrations from the distance of the OCS emission sources. Thus, BOEMRE relies on other government agencies for air quality assessment; their air quality models may not be appropriate for the assessment of air quality from the OCS emission sources.

Water Quality (Chapter 4.1.1.2)

Coastal Waters (Chapter 4.1.1.2.1)

The primary impacting sources to water quality in coastal waters are point-source and storm-water discharges from support facilities, vessel discharges, and nonpoint-source runoff. These activities are not only highly regulated but are localized and temporary in nature. The impacts to coastal water quality from routine activities associated with the CPA proposed action should be minimal as long as all existing regulatory requirements are met.

Accidental events associated with the CPA proposed action that could impact coastal water quality include spills of oil and refined hydrocarbons, releases of natural gas and condensate, and spills of chemicals or drilling fluids. The loss of well control, pipeline failures, collisions, or other malfunctions could also result in such spills. Although response efforts may decrease the amount of oil in the environment, the response efforts may also impact the environment. Natural degradation processes would also decrease the amount of spilled oil over time. For coastal spills, two additional factors that must be considered are the shallowness of the area and the proximity of the spill to shore. Over time, natural processes can physically, chemically, and biologically degrade oil. Chemicals used in the oil and gas industry are not a significant risk in the event of a spill because they are either nontoxic, used in minor quantities, or are only used on a noncontinuous basis. Spills from collisions are not expected to be significant because collisions occur infrequently.

Offshore Waters (Chapter 4.1.1.2.2)

During exploratory activities, the primary impacting sources to offshore water quality are discharges of drilling fluids and cuttings. During platform installation and removal activities, the primary impacting sources to water quality are sediment disturbance and temporarily increased turbidity. Impacting discharges during production activities are produced water and supply-vessel discharges. Existing regulations impose limits on the level of contaminants in these discharges. Pipeline installation can also affect water quality by sediment disturbance and increased turbidity. Service-vessel discharges might include water with oil concentration of approximately 15 ppm as established by regulatory standards. Any disturbance of the seafloor would increase turbidity in the surrounding water, but the increased turbidity should be temporary and restricted to the area near the disturbance. There are multiple Federal regulations and permit requirements that would decrease the magnitude of these activities. Impacts to offshore waters from routine activities associated with the CPA proposed action should be minimal as long as regulatory requirements are followed.

Accidental events associated with the CPA proposed action that could impact offshore water quality include spills of oil and refined hydrocarbons, releases of natural gas and condensate, spills of chemicals

or drilling fluids, and loss of well control, pipeline failures, collisions, or other malfunctions that would result in such spills. Spills from collisions are not expected to be significant because collisions occur infrequently. Overall, loss of well control events and blowouts are rare events, and of short duration, so potential impacts to offshore water quality are not expected to be significant except in the rare case of a catastrophic event. Although response efforts may decrease the amount of oil in the environment, the response efforts may also impact the environment. Natural physical, chemical, and biological processes would decrease the amount of spilled oil over time through dilution, weathering, and degradation of the oil (NRC, 2003). Chemicals used in the oil and gas industry are not a significant risk for a spill because they are either nontoxic, used in minor quantities, or are only used on a noncontinuous basis. Although there is the potential for accidental events, the CPA proposed action would not significantly change the water quality of the Gulf of Mexico over a large spatial or temporal scale.

Coastal Barrier Beaches and Associated Dunes (Chapter 4.1.1.3)

Effects to coastal barrier beaches and associated dunes from pipeline emplacements, navigation channel use and dredging, and construction or continued use of infrastructure in support of the CPA proposed action are expected to be restricted to temporary and localized disturbances. The 0-1 pipeline landfall projected in support of the proposed action is not expected to cause significant impacts to barrier beaches because of the use of nonintrusive installation methods and regulations. New processing plants would not be expected to be constructed on barrier beaches. The proposed action may contribute to the continued use of existing facilities, which can add to erosion. Erosion control structures installed to protect a facility as attended may also accelerate erosion elsewhere in the vicinity.

Maintenance dredging of barrier inlets and bar channels is expected to occur, which combined with channel jetties, causes minor and localized impacts on adjacent barrier beaches. This is due to permit regulations and mitigation efforts. The worst of these situations is found on the sediment-starved coasts of Louisiana, where sediments are largely organic. Despite the fact that maintenance dredging of barrier inlets and bar channels is required due to natural coastal sediment transport processes, the proposed action would account for a small percentage of these impacts.

The CPA proposed action is not expected to adversely alter barrier beach configurations significantly beyond existing, ongoing impacts in localized areas. Strategic placement of dredged material from channel maintenance, channel deepening, and related actions can mitigate adverse impacts upon those localized areas.

Because of the proximity of inshore spills to barrier islands and beaches, inshore spills pose the greatest threat. Such spills may result from either vessel collisions that release fuel and lubricants or from pipelines that rupture. Impacts of a nearshore spill would be considered short term in duration and minor in scope because the size of such a spill is projected to be small (coastal spills are assumed to be 5 bbl; Table 4-13 of the Multisale EIS). Offshore-based crude oil would be less in toxicity when it reaches the coastal environments. This is due to the distance from shore, the weather, the time oil remains offshore, and the dispersant used. Equipment and personnel used in cleanup efforts can generate the greatest direct impacts to the area. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts.

Although the most current information did reveal that some of the barrier islands had experienced storm-induced reductions in beach shoreline elevations and erosion, the significance of this loss of protection is small in comparison with the overriding climatic forces. Therefore, this information would not alter the overall conclusion that impacts on barrier islands and beaches from accidental impacts associated with the CPA proposed action would be minimal. Should a spill other than a catastrophic spill contact a barrier beach, oiling is expected to be light and sand removal during cleanup activities minimized. No significant long-term impacts to the physical shape and structure of barrier beaches and associated dunes are expected to occur as a result of the CPA proposed action. The current lease sale would not pose a significant increase in risk to barrier island or beach resources.

Wetlands (Chapter 4.1.1.4)

The 0-2 km (0-1.2 mi) of onshore pipeline that could result from the proposed action would cause the loss of 0-8 ha (0-20 ac) of wetlands habitat. It is expected that these impacts would be reduced through mitigation, such as horizontal, directional (trenchless) drilling techniques to avoid damages to these

sensitive wetland habitats. Although maintenance dredging of navigation channels and canals in the CPA is expected to occur, the proposed action is expected to contribute minimally to the need for this dredging. Alternative dredged-material disposal methods can be used to enhance and create wetlands. Secondary impacts to wetlands from the CPA proposed action would result from OCS-related vessel traffic contributing to the erosion and widening of navigation channels and canals. This would cause approximately 1 ha (3 ac) of landloss per year. Overall, the impacts to wetlands from routine activities associated with the CPA proposed action are expected to be low due to the small length of projected onshore pipelines, the minimal contribution to the need for maintenance dredging, and because of the mitigation measures that would be used to further reduce these impacts.

In summary, effects to coastal wetlands from the primary impact-producing activities associated with the CPA proposed action are expected to be low. Loss of 0-8 ha (0-20 ac) of wetlands habitat is estimated as a result of 0-2 km (0-1.2 mi) of new pipelines projected as a result of the proposed action. Maintenance dredging of navigation channels and canals is expected to occur with minimal impacts. The proposed action is expected to contribute minimally to the need for this dredging. Alternative dredged-material disposal methods can be used to enhance and create coastal wetlands. Vessel traffic associated with the proposed action is expected to contribute minimally to the erosion and widening of navigation channels and canals. Overall, impacts from these sources are expected to be low and are further reduced through mitigation, such as horizontal, directional (trenchless) drilling techniques, to avoid damages to these sensitive habitats. Secondary impacts to wetlands would be primarily from vessel traffic corridors and would continue to cause approximately 1 ha (3 ac) of landloss per year.

Offshore oil spills resulting from the CPA proposed action are not expected to significantly damage any wetlands along the Gulf Coast. This is because of the distance from the spill to the coast and because wetlands are generally protected by barrier islands, peninsulas, sand spits, and currents. Although the probability of occurrence is low, the greatest threat from an oil spill to wetland habitat is from an inland spill as a result of a vessel accident or pipeline rupture. Wetlands in the northern Gulf of Mexico are either in moderate- to high-energy environments; therefore, sediment transport and tidal stirring should reduce the chances for oil persisting in the event that these areas are oiled. While a resulting slick may cause minor impacts to wetland habitat and surrounding seagrass communities, the equipment, chemical treatments, and personnel used to clean up can generate the greatest impacts to the area. Associated foot traffic may work oil farther into the sediment than would otherwise occur. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. In addition, an assessment of the area covered, oil type, and plant composition of the wetland oiled should be made prior to choosing remediation treatment. These treatments could include mechanical and chemical techniques with onsite technicians. Overall, impacts to wetland habitats from an oil spill associated with activities related to the CPA proposed action would be expected to be low and temporary because of the nature of the system, regulations, and specific cleanup techniques.

Seagrass Communities (Chapter 4.1.1.5)

Routine OCS activities in the CPA are not expected to significantly increase in occurrence and range in the near future. Mitigation reduces undesirable effects on submerged vegetation beds from dredging activities. Permit requirements should ensure that pipeline routes avoid high-salinity beds and maintain water clarity and quality. Local programs decrease the occurrence of prop scarring in grass beds, and channels utilized by OCS vessels are generally away from exposed submerged vegetation beds. Because of these requirements, natural flushing, and implemented programs, any potential effects from routine activities on submerged vegetation in the CPA are expected to be localized and not significantly adverse.

Although the probability of their occurrence is low, the greatest threat to inland, submerged vegetation communities would be from an inland spill resulting from a vessel accident or pipeline rupture. The resulting slick may cause short-term and localized impacts to the bed. There is also the remote possibility of an offshore spill to such an extent that it could also affect submerged vegetation beds, and this would have similar effects to an inshore spill. Because prevention and cleanup measures can have negative effects on submerged vegetation, close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. The floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amount of microorganisms that consume oil would alleviate prolonged effects on submerged vegetation

communities. Also, safety and spill-prevention technologies continue to improve and would decrease detrimental effects to submerged vegetation from the proposed action.

Live Bottoms (Chapter 4.1.1.6)

Live Bottoms (Pinnacle Trend) (Chapter 4.1.1.6.1)

Oil and gas operations discharge drilling muds and cuttings that generate turbidity, potentially smothering benthos near the drill sites. Deposition of drilling muds and cuttings in the Pinnacle Trend area would not greatly impact the biota of the live bottoms because the biota surrounding the pinnacle features are adapted to turbid (nepheloid) conditions and high sedimentation rates associated with the outflow of the Mississippi River. The pinnacles themselves are coated with a veneer of sediment. Regional surface currents and water depth would largely dilute any effluent. Additional deposition and turbidity caused by a nearby well are not expected to adversely affect the pinnacle environment because such fluids would be dispersed upon discharge. Mud contaminants measured in the Pinnacle Trend region reached background levels within 1,500 m (4,921 ft) of the discharge point. Toxic impacts on benthos are limited to within 100-200 m (328-656 ft) of a well, and NPDES permit requirements limit discharge. The drilling of a well from the proposed action, therefore, would have localized impacts on the benthos nearby the well, which should be located away from live-bottom features.

The toxicity of the produced waters has the potential to adversely impact the live-bottom organisms of the Pinnacle Trend; however, as previously stated, the proposed Live Bottom (Pinnacle Trend) Stipulation would prevent the placement of oil and gas facilities upon (and consequently would prevent the discharge of produced water directly over) the Pinnacle Trend live-bottom areas.

Platform removals have the potential to impact nearby habitats. As previously discussed, the platforms are unlikely to be constructed directly on the pinnacles or low-relief areas because of the restraints placed by the Live Bottom (Pinnacle Trend) Stipulation, distancing blasts from sensitive habitats. Benthic organisms on live bottoms should also have limited impact because they are resistant to blasts, tolerant of turbidity, can physically remove some suspended sediment, and may be located above or be tall enough to withstand limited sediment deposition. Live bottoms, however, may be impacted by heavy sediment deposition layers. The implementation of the Live Bottom (Pinnacle Trend) Stipulation would help to prevent such a smothering event. The proposed Live Bottom (Pinnacle Trend) Stipulation could prevent most of the potential impacts on live bottoms from bottom-disturbing activities (structure emplacement and removal) and operational discharges associated with the CPA proposed action in the CPA. Any contaminants that reach live-bottom features would be diluted from their original concentration and impacts that do occur should be sublethal.

Live-bottom features represent a small fraction of the continental shelf area in the CPA. The fact that the live-bottom features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the live-bottom features.

The proposed Live Bottom (Pinnacle Trend) Stipulation (**Chapter 2.4.1.3.2**) would prevent most of the potential impacts from oil and gas operations, including accidental oil spills and blowouts, on the biota of live-bottoms features. However, operations outside the proposed buffer zones around sensitive habitats (including blowouts and oil spills) may affect live-bottom features.

The depth below the sea surface to which many live-bottom features rise helps to protect them from surface oil spills. Some pinnacles may rise to within 40 m (130 ft) of the sea surface; however, many features have much less relief or are in deeper water depths. Any oil that might contact pinnacle features would probably be at low concentrations because the depth to which surface oil can mix down into the water column is less than the peak of the tallest pinnacles, and this would result in little effect to these features.

A subsurface spill or plume may impact sessile biota of live-bottom features. Oil or dispersed oil may cause sublethal impacts to benthic organisms if a plume reaches these features. Impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. The Live Bottom (Pinnacle Trend) Stipulation would limit the potential impact of such occurrences by keeping the sources of such adverse events geographically removed from the sensitive biological resources of live-bottom features.

Sedimented oil or sedimentation as a result of a blowout may impact benthic organisms. However, because the Live Bottom (Pinnacle Trend) Stipulation places petroleum-producing activity at a distance

from live-bottom features, this would result in reduced turbidity and sedimentation. Furthermore, any sedimented oil should be well dispersed, resulting in a light layer of deposition that would be easily removed by the organism and have low toxicity.

The proposed Live Bottom (Pinnacle Trend) Stipulation would assist in preventing most of the potential impacts on live-bottom communities from blowouts, surface, and subsurface oil spills and the associated effects. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a live-bottom feature, the effects would be primarily sublethal and impacts would be at the community level. Any turbidity, sedimentation, and sedimented oil would also be at low concentrations by the time the live-bottom features were reached, resulting in sublethal impacts.

Live Bottoms (Low Relief) (4.1.1.6.2)

Oil and gas operations discharge drilling muds and cuttings that generate turbidity, potentially smothering benthos near the drill sites. Deposition of drilling muds and cuttings near low-relief areas would not greatly impact the biota of the live bottoms because the biota surrounding the low-relief features in or near the CPA are adapted to turbid (nepheloid) conditions and high sedimentation rates associated with the outflow of the Mississippi River. Regional surface currents and water depth would largely dilute any effluent. Additional deposition and turbidity caused by a nearby well are not expected to adversely affect the low-relief environment because such fluids would be dispersed upon discharge. Mud contaminants measured in the region reached background levels within 1,500 m (4,900 ft) of the discharge point. Toxic impacts on benthos are limited to within 100-200 m (328-656 ft) of a well, and NPDES permit requirements limit discharge. The drilling of a well, therefore, would have localized impacts on the benthos near the well, which should be located away from live-bottom features according to the drilling stipulations.

The toxicity of produced waters has the potential to adversely impact the live-bottom organisms; however, as previously stated, many of the low-relief areas are not in the area to be offered in the CPA proposed action, and the proposed Live Bottom (Low Relief) Stipulation would prevent the placement of oil and gas facilities upon (and consequently would prevent the discharge of produced water directly over) low-relief, live-bottom habitats.

Platform removals have the potential to impact nearby habitats. As previously discussed, the platforms would not be constructed directly on low-relief areas because these areas are either not included in the area to be offered in the CPA proposed action or are protected by the Live Bottom (Low Relief) Stipulation, distancing blasts from sensitive low-relief habitats. Benthic organisms on live bottoms should also have limited impact because they are resistant to blasts, tolerant of turbidity, can physically remove some suspended sediment, and may be located above or be tall enough to withstand limited sediment deposition. The implementation of the Live Bottom (Low Relief) Stipulation would help to prevent smothering events. Since the live-bottom areas are either not included in the area to be offered in the CPA proposed action or are protected by the Live Bottom (Low Relief) Stipulation, most of the potential impacts on live bottoms from bottom-disturbing activities (structure emplacement and removal) and operational discharges associated with the CPA proposed action would be prevented. Any contaminants that reach live-bottom features would be diluted from their original concentration, so impacts that do occur should be sublethal.

Live-bottom features represent a small fraction of the continental shelf area in the CPA. The fact that the live-bottom features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the live-bottom features.

The depth below the sea surface to which many live-bottom features rise helps to protect them from surface oil spills. Because the concentration of oil becomes diluted as it physically mixes with the surrounding water and as it moves into the water column, any oil that might be driven to 10 m (33 ft) or deeper would probably be at concentrations low enough to reduce impact to these features. Features in water shallower than 10 m (33 ft) would be far from the source of activities in the CPA proposed action.

A subsurface spill or plume may impact sessile biota of live-bottom features. Oil or dispersed oil may cause sublethal impacts to benthic organisms if a plume reaches these features. Impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive

success. The distance of proposed activities from low-relief live bottoms provides considerable protection for the habitats. The Live Bottom (Low Relief) Stipulation would limit the potential impact of any activities that may approach low-relief habitats (such as pipeline right-of-ways) because the stipulation keeps the sources of such adverse events geographically removed from the sensitive biological resources of live-bottom features. The distance would serve to reduce turbidity and sedimentation, and any sedimented oil should be well dispersed, resulting in a light layer of deposition that would have low toxicity and be easily removed by the organism.

The proposed Live Bottom (Low Relief) Stipulation would assist in preventing most of the potential impacts on live-bottom communities from blowouts, surface, and subsurface oil spills and the associated effects. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a live-bottom feature, the effects would be primarily sublethal and impacts would be at the community level. Any turbidity, sedimentation, and sedimented oil would also be at low concentrations by the time the live-bottom features were reached, resulting in sub-lethal impacts.

Topographic Features (Chapter 4.1.1.7)

The proposed Topographic Features Stipulation would prevent most of the potential impacts on topographic features from bottom-disturbing activities (structure removal and emplacement) and operational discharges associated with the CPA proposed action. Because of the No Activity Zone, permit restrictions, and the high-energy environment associated with topographic features, if any contaminants reach topographic features, they would be diluted from their original concentration and impacts that do occur would be minimal.

The proposed Topographic Features Stipulation would assist in preventing most of the potential impacts on topographic feature communities from blowouts, surface, and subsurface oil spills and the associated effects by increasing the distance of such events from the topographic features. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a topographic feature, the effects would be primarily sublethal and the impacts would be at the community level. Any turbidity, sedimentation, and oil adsorbed to sediments would also be at low concentrations by the time the topographic features were reached, also resulting in sublethal impacts. Impacts from an oil spill on topographic features are also lessened by the distance of the spill to the features, the depth of the features, and the currents that surround the features.

Sargassum (Chapter 4.1.1.8)

Sargassum, as pelagic algae, is a widely distributed resource that is ubiquitous throughout the GOM and northwest Atlantic. Considering its ubiquitous distribution and occurrence in the upper water column near the sea surface, it would be contacted by routine discharges from oil and gas operations. All types of discharges including drill muds and cuttings, produced water, and operational discharges (e.g., deck runoff, bilge water, sanitary effluent, etc.) would contact *Sargassum* algae. However, the quantity and volume of these discharges is relatively small compared with the pelagic waters of the CPA (268,922 km^2; 103,831 mi^2). Therefore, although discharges would contact *Sargassum*, they would only contact a very small portion of the *Sargassum* population. Because these discharges are highly regulated for toxicity and because they would continue to be diluted in the Gulf water, concentrations of any toxic components would be reduced; therefore, produced water impacts on *Sargassum* would be minimum. Likewise, impingement effects by service vessels and working platforms and drillships would contact only a very small portion of the *Sargassum* population. The impacts to *Sargassum* that are associated with the proposed action are expected to have only minor effects to a small portion of the *Sargassum* community as a whole. The *Sargassum* community lives in pelagic waters with generally high water quality and would be resilient to the minor effects predicted. It has a yearly cycle that promotes quick recovery from impacts. No measurable impacts are expected to the overall population of the *Sargassum* community.

Considering its ubiquitous distribution and occurrence in the upper water column near the sea surface, *Sargassum* would contact potential accidental spills from oil and gas operations. All types of spills

including surface oil and fuel spills, underwater well blowouts, and chemical spills would contact *Sargassum* algae. The quantity and volume of most of these spills would be relatively small compared with the pelagic waters of the CPA (268,922 km^2 [103,831 mi^2] of the CPA). Therefore, most spills would only contact a very small portion of the *Sargassum* population. The impacts to *Sargassum* that are associated with the proposed action are expected to have only minor effects to a small portion of the *Sargassum* community as a whole unless a catastrophic spill occurs. In the case of a very large spill, the *Sargassum* algae community could suffer severe impacts to a sizable portion of the population in the northern GOM. No measurable impacts are expected to the overall population of the *Sargassum* community unless a catastrophic spill occurs.

Chemosynthetic Deepwater Benthic Communities (Chapter 4.1.1.9)

Chemosynthetic communities are susceptible to physical impacts from structure placement (including templates or subsea completions), anchoring, and pipeline installation. Because of the avoidance policies described in NTL 2009-G40, the risk of these physical impacts are greatly reduced by requiring the avoidance of potential chemosynthetic communities.

Chemosynthetic communities could be susceptible to physical impacts from a blowout depending on bottom-current conditions. The guidance provided in NTL 2009-G40 greatly reduces the risk of these physical impacts. It clarifies the requirement to avoid potential chemosynthetic communities identified on the required geophysical survey records or photodocumentation to establish the absence of chemosynthetic communities prior to approval of the structure emplacement.

Studies indicate that periods as long as hundreds of years are required to reestablish a seep community once it has disappeared (depending on the community type). There is evidence that substantial impacts on these communities could permanently prevent reestablishment, particularly if hard substrate required for recolonization was buried by resuspended sediments from a blowout.

Potential accidental impacts from the CPA proposed action are expected to cause little damage to the ecological function or biological productivity of widespread, low-density chemosynthetic communities. The rarer, widely scattered, high-density, Bush Hill-type chemosynthetic communities located at more than 610 m (2,000 ft) away from a blowout could experience minor impacts from resuspended sediments. However, the possibility of oil from a surface spill reaching a depth of 300 m (984 ft) or greater in any measurable concentration is very small. If dispersants are applied to an oil spill, oil would mix into the water column, be carried by underwater currents, and eventually contact the seafloor where it may impact patches of chemosynthetic community habitat in its path.

The BOEMRE has reexamined the analysis for impacts to chemosynthetic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found to indicate that accidental impacts associated with the CPA proposed action would result in more than minimal impacts to chemosynthetic communities because of the NTL 2009-G40 guidelines. One exception would be in the case of a catastrophic spill combined with the application of dispersant, producing the potential to cause devastating effects on local patches of habitat in the path of subsea plumes where they contact the seafloor.

Nonchemosynthetic Deepwater Benthic Communities (Chapter 4.1.1.10)

Some impact to soft-bottom benthic communities from drilling and production activities would occur as a result of physical impact from drilling discharges, structure placement (including templates or subsea completions), anchoring, and installation of pipelines regardless of their locations. However, even in situations where the substantial burial of typical benthic infaunal communities occurred, recolonization from populations from widespread neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms.

Impacts to other hard-bottom communities are expected to be avoided as a consequence of the application of the existing NTL 2009-G40 guidelines for chemosynthetic communities. The same geophysical conditions associated with the potential presence of chemosynthetic communities also results in the potential occurrence of hard carbonate substrate and nonchemosynthetic communities. Because of the NTL 2009-G40 guideline, these are generally avoided in exploration and development planning.

Accidental events resulting from the CPA proposed action are expected to cause little damage to the ecological function or biological productivity of widespread, typical, deep-sea benthic communities.

Some impact to benthic communities would occur as a result of impact from an accidental blowout. Megafauna and infauna communities at or below the sediment/water interface would be impacted by the physical disturbance of a blowout or by burial from resuspended sediments. However, even in situations where the substantial burial of typical soft benthic communities occurred, recolonization by populations from neighboring substrate would be expected over a relatively short period of time. For all size ranges of organisms, this can be in a matter of hours to days for bacteria and about 1-2 years for most all macrofauna species.

Impacts to deepwater coral habitats and other potential hard-bottom communities would likely be avoided as a consequence of the application of the policies described in NTL 2009-G40. The rare, widely scattered, high-density, Bush Hill-type nonchemosynthetic communities located at more than 610 m (2,000 ft) away from a blowout could experience minor impacts from resuspended sediments. If dispersants are applied to an oil spill oil would mix into the water column, be carried by underwater currents, and eventually contact the seafloor where it may impact patches of sensitive deepwater community habitat in its path. These potential impacts would be localized due to the directional movement of oil plumes by the water currents and because the sensitive habitats have a scattered, patchy distribution.

The BOEMRE has reexamined the analysis for impacts to nonchemosynthetic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found that would alter the overall conclusion that impacts on nonchemosynthetic communities from routine activities associated with the CPA proposed action would be minimal to none.

Marine Mammals (Chapter 4.1.1.11)

In this Supplemental EIS, BOEMRE has reexamined the analysis for marine mammals presented in the Multisale EIS and the 2009-2012 Supplemental EIS and has considered the recent reports cited in **Chapter 4.1.1.11** and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM on the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

Mysticetes, as low-frequency hearing specialists, are the species groups most likely to be susceptible to impacts from nonpulse sound (intermittent or continuous), given that their hearing ranges overlap most closely with the noise frequencies produced from drilling. However, most mysticete species that may occur in the GOM (i.e., North Atlantic right, blue, fin, sei, humpback, and minke whales) are considered either "extralimital," "rare," or "uncommon"; however, a small population of Bryde's whales are common in the eastern GOM. Because of the geographic scope of the proposed action, the presence of these species within the action area is unlikely.

The remaining marine mammal species in the GOM (e.g., sperm whales, dwarf or pygmy sperm whales, and dolphins) are considered mid-frequency hearing specialists, with hearing ranges that slightly overlap with sound frequencies produced from drilling noise. It is expected that there would be some overlap in the frequencies of the drill source and the hearing thresholds of the marine mammals present in the GOM. The broadband frequencies of semisubmersible drill vessels are estimated to be from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1μPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB. Bottlenose dolphins have hearing thresholds ranging from less than 5 kHz to over 100 kHz. Through auditory brainstem analysis, it was found that pygmy sperm whales have thresholds from 90 to 150 kHz. A stranded sperm whale was found to have lower hearing limits at around 100 Hz, while a sperm whale calf was found to have had best hearing sensitivity between 5 and 20 kHz. Since there is some overlap in the sound levels produced and the

hearing thresholds of marine mammals, there is potential for the drilling noise produced to cause auditory and nonauditory effects, permanent threshold shift, temporary threshold shift, behavioral changes, or masking; but it is expected to be limited. However, these levels are under the NMFS 160-dB level B harassment under the MMPA.

The NMFS sets the 180-dB, root-mean-squared (rms) isopleth where on-set of auditory injury or mortality (level A harassment) to cetaceans may occur. It is suggested that this level should rather be at 230 dB rms for a nonpulsed sound, such as drilling noise. Drilling from semisubmersible vessels have estimated broadband frequencies from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1microPa at 1 m. Tones of 60 Hz have source levels of 149 dB, while 181 Hz have source levels of 137 dB, and 301 Hz have source levels of 136 dB. These source levels all fall below the 180-dB level A harassment isopleths.

Because of the mitigations described in **Chapter 4.1.1.11**, routine activities (e.g., operational discharges, noise, vessel traffic, and marine debris) related to the proposed CPA lease sale are not expected to have long-term adverse effects on the size and productivity of any marine mammal species or population in the northern GOM. Lethal effects are most likely to be from chance collisions with OCS service vessels or ingestion of any accidentally released plastic materials. Most routine OCS activities are expected to have sublethal effects. In conclusion, the scope, timing, and transitory nature of the proposed action and the mitigation and monitoring requirements in place, the noise related to the CPA proposed action is not expected to result in permanent threshold shift, temporary threshold shift, behavioral change, masking, or nonauditory effects to marine mammals in the GOM that would rise to the level of significance.

In the event of a catastrophic spill similar to the DWH event, any substantive impact to marine mammals is very unlikely because the potential impacts from a catastrophic spill would be similar to the routine and accidental issues described in **Chapters 4.1.1.11.2 and 4.1.1.11.3**, respectively. However, despite the recent DWH event, historical trends in the GOM indicate that catastrophic spill events are not likely to occur as a result of drilling and temporary abandonment.

Sea Turtles (Chapter 4.1.1.12)

In this Supplemental EIS, BOEMRE has reexamined the analysis for sea turtles presented in the Multisale EIS and the 2009-2012 Supplemental EIS and has considered the recent reports cited in **Chapter 4.1.1.12** and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. In the interim, BOEMRE will continue to comply with all Reasonable and Prudent Measures and the Terms and Conditions under these existing consultations, along with implementing the current BOEMRE-imposed mitigation, monitoring, and reporting requirements. Based on the most recent and best available information at the time, BOEMRE will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes.

Because of the mitigations described in **Chapter 4.1.1.12**, routine activities (e.g., operational discharges, noise, vessel traffic, and marine debris) related to the proposed CPA lease sale are not expected to have long-term adverse effects on the size and productivity of any sea turtle species or populations in the northern GOM. Lethal effects are most likely to be from chance collisions with OCS service vessels or ingestion of accidentally-released plastic materials. Most OCS activities are expected to have sublethal effects.

With current regulations, mitigation, and the low probability of an accidental event, effects on turtle populations from a CPA proposed action are expected to be small. In the event of a catastrophic spill similar to the DWH event, any substantive impact to sea turtles is very unlikely because the potential impacts from a catastrophic spill would be similar to the routine and accidental issues described in

Chapters 4.1.1.12.2 and 4.1.1.12.3, respectively. However, despite the recent DWH event, historical trends in the GOM indicate that catastrophic spill events are not likely to occur as a result of drilling and temporary abandonment associated with the CPA proposed action.

Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice (4.1.1.13)

An impact from the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but unlikely. Impact may result from consumption of beach trash and debris. Because the proposed action would deposit only a small portion of the total debris that would reach the habitat, the impacts would be minimal. Unless all personnel are adequately trained, efforts undertaken for the removal of marine debris may temporarily scare away beach mice or destroy their food resources such as sea oats. However, their burrows are about 1-3 m (3-10 ft) long and involve a plugged escape tunnel, which would function after the main burrow entrance was trampled by foot traffic of insufficiently trained debris cleanup personnel.

The oiling of beach mice could result in local extinction. Oil-spill-response and cleanup activities could also have a substantial impact to the beach mice and their habitat if not properly regulated. However, potential spills that could result from the proposed action are not expected to contact beach mice or their habitats (<0.5% probability). Also, inshore facilities related to the proposed action are unlikely to be located on beach mouse habitat.

Within the last 20-30 years, the combination of habitat loss due to beachfront development, isolation of remaining beach mouse habitat areas and populations, and destruction of remaining habitat by tropical storms and hurricanes has increased the threat of extinction of several subspecies of beach mice. Destruction of the remaining habitat due to a catastrophic spill and cleanup activities would increase the threat of extinction, but the potential for a catastrophic spill that would affect beach mice habitat is low.

Coastal and Marine Birds (Chapter 4.1.1.14)

The majority of effects resulting from routine activities with the CPA proposed action on endangered/threatened and nonendangered/nonthreatened coastal and marine birds are expected to be sublethal. These effects include behavioral effects, exposure to or intake of OCS-related contaminants or discarded debris, temporary disturbances, and displacement of localized groups from impacted habitats. Chronic sublethal stress, however, is often undetectable in birds. As a result of stress, individuals may weaken, facilitating infection and disease; migratory species may then not have the energetic reserves necessary to complete their migration. Nocturnal circulation around platforms, under certain circumstances, may create acute sublethal stress from energy loss and increase the risks of collision, while stopovers on platforms would reduce energy loss. Because of regulatory standards for air and water quality as discussed in **Chapters 4.1.1.1, 4.1.1.2.1, and 4.1.1.2.2**, emissions or produced waters should have a small effect on birds. No significant habitat impacts are expected to occur directly from routine activities resulting from the CPA proposed action because of the distance of these activities from shore. Secondary impacts from pipeline and navigation canals to coastal habitats would occur over the long term and may ultimately displace members of some species. These activities would occur whether the proposed action was implemented or not; therefore, the proposed action itself would not increase these secondary impacts to birds.

Oil spills have the greatest impact on coastal and marine birds. Small amounts of oil can affect birds, and mortality from oil spills is often related to numerous symptoms of toxicity. Data from actual spills strongly suggest that impacts on their food supply are delayed after initial impacts from direct oiling. Mechanisms of toxic oil effects other than direct oiling of plumage have seldom been confirmed. Oil-spill impacts on birds from the CPA proposed action are expected to be negligible because oil spills would only affect a small portion of a bird group. Impacts of oil-spill cleanup from the proposed action are also expected to be negligible.

Gulf Sturgeon (Chapter 4.1.1.15)

Potential routine impacts on Gulf sturgeon and their designated critical habitat may occur from drilling and produced-water discharges, bottom degradation of estuarine and marine water quality by nonpoint runoff from estuarine OCS-related facilities, vessel traffic, explosive removal of structures, and

pipeline installation. Because of the permitted discharge limits mandated and enforced in the Federal and State regulatory process, the dilution and low toxicity of this pollution is expected to result in negligible impact of the CPA proposed action on Gulf sturgeon. Vessel traffic would generally only pose a risk to Gulf sturgeon when leaving and returning to port. Major navigation channels are excluded from critical habitat. Also, the Gulf sturgeon characteristics of bottom-feeding and general avoidance of disturbance make the probability of vessel strike extremely remote. Explosive removal of structures as a result of the proposed action would occur well offshore of Gulf sturgeon's critical habitat and the riverine, estuarine, and shallow Gulf habitats where sturgeon are generally located. If any pipeline is installed nearshore as a result of the proposed action, regulatory permit requirements governing pipeline placement and dredging, as well as recent noninvasive techniques for locating pipelines, would result in very minimal impact to the Gulf sturgeon's critical habitat. Due to regulations, mitigations, and the distance of routine activities from known Gulf sturgeon habitats, impacts from routine activities of the CPA proposed action would be expected to have negligible effects on Gulf sturgeon and their designated critical habitat.

The Gulf sturgeon could be impacted by oil spills resulting from the CPA proposed action. If there is contact with spilled oil, it could have detrimental physiological effects. The juvenile and subadult Gulf sturgeon, at a minimum, seasonally use the nearshore coastal waters and could potentially be at risk from both coastal and offshore spills. Due to the distance of the activity from shore and Gulf sturgeon critical habitat, there is a minimal risk of any oil coming in contact with Gulf sturgeon. The probability of a spill of a size and duration to persist long enough in the environment to impact the sturgeon or the sturgeon's estuarine habitats is small (≤10%; Figure 3-10 of the 2009-2012 Supplemental EIS) unless it is catastrophic in nature such as the DWH event. In the rare event contact with oil occurs, this could cause nonlethal effects including fish temporarily migrating from the affected area, irritation of gill epithelium, and an increase of liver function in a few adults, and possibly interference with reproductive activity.

The formal consultation with NMFS was concluded with the Biological Opinion dated June 29, 2007, and received by BOEMRE on July 3, 2007. The Biological Opinion concludes that the proposed lease sales and associated activities in the GOM in the 5-Year Program, which includes the current leasing area concurred with BOEMRE that the proposed actions would not adversely impact the endangered Gulf sturgeon or its critical habitat. Following the DWH event, BOEMRE requested reinitiation of ESA consultation with both NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010. The FWS responded with a letter to BOEMRE on September 27, 2010. The reinitiated consultations are not complete at this time; however, BOEMRE is in discussions with both agencies.

Fish Resources and Essential Fish Habitat (Chapter 4.1.1.16)

It is expected that any possible coastal and marine environmental degradation from the CPA proposed action would have little effect on fish resources or EFH. The impact of coastal and marine environmental degradation is not expected to cause a detectable decrease in fish resources or in EFH. Routine activities such as pipeline trenching and OCS discharge of drilling muds and produced water would cause negligible impacts and would not deleteriously affect fish resources or EFH. This is because mitigation reduces undesirable effects on coastal habitats from dredging and other construction activities. Permit requirements should ensure pipeline routes either avoid different coastal habitat types or certain techniques are used to decrease impacts. At the expected level of impact, the resultant influence on fish resources would cause minimal changes in fish populations or EFH. That is, if there are impacts, they would be short-term and localized; therefore, they would only affect small portions of fish populations and selected areas of EFH. As a result, there would be little disturbance to fish resources or EFH. In deepwater areas, many of the EFH's are protected under stipulations and regulations currently set in place.

The BOEMRE has reexamined the analysis for impacts to fish resources and EFH presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information described in **Chapter 4.1.1.16.2**. No substantial new information was found that would alter the overall conclusion that impacts to fish resources and EFH from routine activities associated with the CPA proposed action would be minimal to none. The CPA proposed action is expected to result in a minimal decrease in fish resources and/or standing stocks or in EFH. It would require a short time for fish resources to recover from most of the impacts, but the loss of wetlands as EFH could be permanent.

Additional hard substrate habitat provided by structure installation in areas where natural hard bottom is rare would tend to increase fish populations. The removal of these structures would eliminate that habitat, except when decommissioned platforms are used as artificial reef material. This practice is expected to increase over time.

Accidental events that could impact fish resources and EFH include blowouts and oil or chemical spills. Subsurface blowouts, although highly unlikely, have the potential to adversely affect fish resources. If spills due to the CPA proposed action were to occur in open waters of the OCS proximate to mobile adult finfish or shellfish, the effects would likely be nonfatal and the extent of damage would be reduced due to the capability of adult fish and shellfish to avoid a spill, to metabolize hydrocarbons, and to excrete both metabolites and parent compounds. Fish populations may be impacted by an oil spill, but they would be primarily affected if the oil reaches the productive shelf and estuarine areas; this probability is generally low. Also, much of the coastal northern Gulf of Mexico is a moderate- to high-energy environment; therefore, sediment transport and tidal stirring should reduce the chances for oil persisting in these habitats if they are oiled. Early life stages of animals are usually more sensitive to environmental stress than adults. Oil can be lethal to fish, especially in larval and egg stages, depending on the time of the year that the event happened. The extent of the impacts of the oil would depend on the properties of the oil and the time of year of the event.

Fisheries closures may result from a large spill event. These closures may have a negative effect on short-term fisheries catch and/or marketability. In the long term, they may have a positive impact on species populations.

The effect of proposed-action-related oil spills on fish resources is expected to cause a minimal decrease in standing stocks of any population because most spill events would be localized; therefore, they would affect a small portion of fish populations. Historically, there have been no oil spills of any size that have had a long-term impact on fishery populations. Although many potential effects of the DWH event on the fish populations of the Gulf of Mexico have been alleged, the actual effects are at this time unknown, and the total impacts are likely to be unknown for several years.

Commercial Fishing (Chapter 4.1.1.17)

Routine activities such as seismic surveys and pipeline trenching in the CPA would cause negligible impacts and would not deleteriously affect commercial fishing activities. Because seismic surveys are temporary events, they are not expected to cause long-term or permanent displacement of any listed species from critical/preferred habitat or to result in the destruction or adverse modification of critical habitat or EFH. Operations such as production platform emplacement, underwater OCS impediments, and explosive platform removal would cause slightly greater impacts on commercial fishing, but their effects are localized to a small percentage of area fished and are temporary in nature.

Commercial catches by species and by State have been updated in **Chapter 4.1.1.17.1**, as have the impacts of the 2005 and 2008 hurricanes on fish and fish habitat from recent reports. The new information presented in this Supplemental EIS does not alter the conclusion presented in the Multisale EIS and the 2009-2012 Supplemental EIS that impacts on commercial fisheries from routine activities associated with the CPA proposed action would be minimal.

The BOEMRE has reexamined the analysis for impacts to commercial fish resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on updated information obtained through the peer-reviewed data, Internet sources, and conversations with Gulf Coast State agencies, Federal agencies, and professors at local academic institutions. No substantial newly published, peer-reviewed information was found that would alter the overall conclusion that impacts to commercial fish resources from accidental activities associated with the CPA proposed action would be minimal. In summary, the impacts of the CPA proposed action from accidental events (i.e., a well blowout or an oil spill) are anticipated to be minimal because the potential for oil spills is very low.

Fish populations may be impacted by an oil-spill event should it occur, but they would be primarily affected if the oil reaches the productive shelf and estuarine areas. The probability of an offshore spill impacting these nearshore environments is also low, and oil would generally be volatilized or dispersed by currents in the offshore environment. Extent of the impacts of the oil would depend on the properties of the oil and the time of year of the event.

Commercial fishermen are anticipated to avoid the area of a well blowout or an oil spill. Fisheries closures may result from a large spill event. These closures may have a negative effect on short term fisheries catch and/or marketability. In the long term, they may have a positive impact on annually harvested because there was a decrease in fishing pressure on the stocks.

Recreational Fishing (Chapter 4.1.1.18)

There could be minor and short-term, space-use conflicts with recreational fishermen during the initial phases of the CPA proposed action. The proposed action could also lead to low-level environmental degradation of fish habitat (**Chapter 4.1.1.16.2**), which would also negatively impact recreational fishing activity. However, these minor negative effects would likely be outweighed by the beneficial role that oil rigs serve as artificial reefs for fish populations. Each structure placed during the CPA proposed action has the potential to function as a *de facto* artificial reef. The degree to which oil platforms would become a part of a particular State's rigs-to-reefs program would be an important determinant of the degree to which the proposed action would impact recreational fishing activity in the long term.

An oil spill would likely lead to recreational fishing closures in the vicinity of the oil spill. Small-scale spills should not affect recreational fishing to a large degree due to the likely availability of substitute fishing sites in neighboring regions. A rare large spill such as the one associated with the DWH event can have more noticeable effects because of the larger potential closure regions and because of the wider economic implications such closures can have. However, the longer-term implications of a large oil spill would primarily depend on the extent to which fish ecosystems recover after the spill has been cleaned. Because offshore spills have a small probability of contacting estuarine habitats that serve as nurseries for many recreational species and because inshore spills would have localized impacts to an area, oil spills would have a small effect on recreational fisheries.

Recreational Resources (Chapter 4.1.1.19)

Routine OCS actions in the CPA could cause minor disturbances to recreational resources, particularly beaches, through increased levels of noise, debris, and rig visibility. Because offshore spills have a small probability of contacting estuarine habitats that serve as nurseries for many recreational species and because inshore spills would have localized impacts to an area, oil spills would have a small effect on recreational fisheries. Routine activities could also cause minor changes to the composition of local economies through changes in employment, land-use, and recreation demand. The CPA proposed action has the potential to directly and indirectly impact recreational resources along the coastal areas adjacent to the CPA. However, the small scale of OCS activities relative to the scale of the existing oil and gas industry is such that these potential impacts on recreational resources are likely to be minimal.

Spills most likely to result from the CPA proposed action would be small, of short duration, and not likely to impact Gulf Coast recreational resources. Should an oil spill occur and contact a beach area or other recreational resource, it would cause some disruption during the impact and cleanup phases of the spill. However, these effects are also likely to be small in scale and of short duration. This is because the size of a coastal spill is projected to be small (coastal spills are assumed to be 5 bbl; Table 4-13 of the Multisale EIS), and the probability of an offshore spill contacting most beaches is small. In the unlikely event that a spill occurs that is sufficiently large to affect large areas of the coast and, through public perception, have effects that reach beyond the damaged area, effects to recreation and tourism could be significant. The DWH event was such a case; the resulting spill damaged some coastal resources but had economic effects in a much larger area. The role of perceptions on tourism activity was a particularly important feature of the DWH event, one that should become better understood as the aftermath of the spill unfolds.

Archaeological Resources (Chapter 4.1.1.20)

The BOEMRE has reexamined the analysis for archaeological resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS. This Supplemental EIS is based upon additional information available since the publication of these two documents and in consideration of the DWH event. Substantial new information that alters the impact conclusion for archaeological resources presented in

the Multisale EIS and the 2009-2012 Supplemental EIS has come to light as a result of BOEMRE-sponsored studies and industry surveys; specifically, reports of damage to significant cultural resources (i.e., historic shipwrecks) have been confirmed in lease areas >200 m (656 ft) deep where no survey data was available. Although the exact cause of this damage is unknown, it may be linked to postlease, bottom-disturbing activities. As part of the environmental reviews conducted for postlease activities, available information will be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if mitigation is warranted.

Historic (4.1.1.20.1)

The greatest potential impact to an archaeological resource as a result of the CPA proposed action would result from direct contact between an offshore activity (i.e., platform installation, drilling rig emplacement, and dredging or pipeline project) and a historic site. Archaeological surveys, where required prior to an operator beginning oil and gas activities on a lease, are expected to be effective at identifying possible archaeological sites. The technical requirements of the archaeological resource reports are detailed in NTL 2005-G07, "Archaeological Resource Surveys and Reports." Under 30 CFR 250.194(c) and 30 CFR 250.1010(c), lessees are required to notify this Agency immediately of the discovery of any potential archaeological resources.

Offshore oil and gas activities resulting from the proposed action could impact an archaeological resource because of incomplete knowledge on the location of these sites in the Gulf. The risk of contact to archaeological resources is greater in instances where archaeological survey data is unavailable. Such an event could result in the disturbance or destruction of important archaeological information. Archaeological surveys, where required, would provide the necessary information to develop avoidance strategies that would reduce the potential for impacts on archaeological resources.

Except for the projected 0-1 new gas processing plants and 0-1 new pipeline landfall, the CPA proposed action would require no new oil and gas coastal infrastructure. It is expected that archaeological resources would be protected through the review and approval processes of the various Federal, State, and local agencies involved in permitting onshore activities.

Accidental events producing oil spills may threaten archaeological resources along the Gulf Coast. Should a spill contact an historic archaeological site (including submerged sites), damage might include direct impact from oil-spill cleanup equipment, contamination of materials, and/or looting. The major effect from an oil-spill impact would be visual contamination of a historic coastal site, such as a historic fort or lighthouse. It is expected that any spill cleanup operations would be considered a Federal action for the purposes of Section 106 of the NHPA and would be conducted in such a way as to cause little or no impacts to historic archaeological resources. Recent research suggests the impact of direct contact of oil on historic properties may be long term and not easily reversible without risking damage to fragile historic materials. Previously unrecorded sites could be impacted by oil-spill cleanup operations on beaches. As indicated in Chapter 4.3.1.8 of the Multisale EIS, it is not very likely for an oil spill to occur and contact submerged, coastal, or barrier island historic sites as a result of the CPA proposed action. The potential for spills is low, the effects would generally be temporary and localized, and the cleanup efforts would be regulated.

The proposed action is not expected to result in impacts to historic archaeological sites; however, should such an impact occur, unique or significant archaeological information could be lost and this impact could be irreversible.

Prehistoric (Chapter 4.1.1.20.2)

The greatest potential impact to an archaeological resource as a result of the CPA proposed action would result from direct contact between an offshore activity (i.e., platform installation, drilling rig emplacement, and dredging or pipeline project) and a prehistoric site. Prehistoric archaeological sites are thought potentially to be preserved shoreward of the 45-m (148-ft) bathymetric contour, where the Gulf of Mexico continental shelf was subaerially exposed during the Late Pleistocene. The archaeological survey and archaeological clearance of sites required prior to an operator beginning oil and gas activities on a lease are expected to be somewhat effective at identifying submerged landforms that could support possible archaeological sites. The NTL 2005-G07 provides guidance for establishing a 300-m (984-ft) linespacing for remote-sensing surveys of leases within areas having a high potential for prehistoric sites.

While the survey and clearance provide a reduction in the potential for a damaging interaction between an impact-producing factor and a prehistoric archaeological site, there is a possibility of an OCS activity contacting an archaeological site because of an insufficiently dense survey grid. Should such contact occur, there would be damage to or loss of significant and/or unique archaeological information. Except for the projected 0-1 new gas processing plants and 0-1 new pipeline landfall, the CPA proposed action would require no new oil and gas coastal infrastructure. It is expected that archaeological resources would be protected through the review and approval processes of the various Federal, State, and local agencies involved in permitting onshore activities.

Accidental events producing oil spills may threaten archaeological resources along the Gulf Coast. Should a spill contact a prehistoric archaeological site, damage might include loss of radiocarbon-dating potential, direct impact from oil-spill cleanup equipment, and/or looting. Previously unrecorded sites could be impacted by oil-spill cleanup operations on beaches. As indicated in Chapter 4.3.1.8 of the Multisale EIS, it is not very likely for an oil spill to occur and contact coastal and barrier island prehistoric sites as a result of the CPA proposed action. The proposed action, therefore, is not expected to result in impacts to prehistoric archaeological sites.

Human Resources and Land Use (Chapter 4.1.1.21)

Land Use and Coastal Infrastructure (Chapter 4.1.1.21.1)

The impacts of routine events associated with the CPA proposed action are uncertain due to the post-DWH event environment, lingering effects of the drilling suspensions, changes in Federal requirements for drilling safety, and temporary interruption of the permit approval process. The BOEMRE projects 0-1 new gas processing facilities and 0-1 new pipeline landfalls for the proposed action. However, based on the most current information available, there is a very slim chance that either would result from the CPA proposed action, and if a new gas processing facility or pipeline landfall were to result, it would likely occur toward the end of the 40-year analysis period. The likelihood of a new gas processing facility or pipeline landfall is much closer to zero than to one. The BOEMRE anticipates that there would be maintenance dredging of navigation channels and an increase in activity at services bases as a result of the CPA proposed action. If drilling activity recovers post-DWH event and increases, there could be new increased demand for a waste disposal services as a result of the CPA proposed action. Because of the current near zero estimates for pipeline landfalls and processing facility construction, the routine activities associated with the CPA proposed action would have little effect on land use.

As a result of the DWH event, it is too early to determine substantial, long-term changes in routine event impacts to land use and infrastructure. The BOEMRE anticipates these changes would become apparent over time. Therefore, BOEMRE recognizes the need to continue monitoring all resources for changes that are applicable for land use and infrastructure. From the information that is currently available, in regard to land use and infrastructure, it does not appear that there would be adverse impacts from routine events associated with the CPA proposed action.

Many of the impacts of the DWH event to land use and infrastructure have been temporary and short-term, such as the ship decontamination sites and the waste staging areas established in the immediate aftermath of the DWH event. The indirect effects on infrastructure use are still rippling through the industry, but this should be resolved as issues with the suspensions, permitting, etc. are resolved. With regards to land use and infrastructure, the post-DWH event environment remains somewhat dynamic, and BOEMRE will continue to monitor these resources over time and to document short- and long-term DWH event impacts. In the future, the long-term impacts of the DWH event will be clearer as time allows the production of peer-reviewed research and targeted studies that determine those impacts. The DWH event was a low-probability, high-impact catastrophic event. For the reasons set forth in the analysis above, the kinds of accidental events that are likely to result from the CPA proposed action are not likely to significantly affect land use and coastal infrastructure. This is because accidental events offshore would have a small probability of impacting onshore resources. Also, if an accident occurs nearshore, it would be most probably be near a facility; therefore, the impacts would be temporary and localized because of the decrease in response time.

Demographics (Chapter 4.1.1.21.2)

The CPA proposed action is projected to minimally affect the demography of the analysis area. Population impacts from the proposed action are projected to be minimal (<1% of the total population) for any economic impact area (EIA) in the Gulf of Mexico region (**Figure 2-2**). The baseline population patterns and distributions, as projected and described in **Chapter 4.1.1.21.2.1**, are expected to remain unchanged as a result of the CPA proposed action. The increase in employment is expected to be met primarily with the existing population and available labor force, with the exception of some in-migration projected to occur in focal areas, such as Port Fourchon.

Accidental events associated with the CPA proposed action, such as oil or chemical spills, blowouts, and vessel collisions, would likely have no effects on the demographic characteristics of the Gulf coastal communities. This is because net employment impacts from a spill are not expected to exceed 1 percent of baseline employment for any EIA in any given year, even if they are included with employment associated with routine oil and gas development activities associated with the CPA proposed action and if population changes are derived from employment changes.

Economic Factors (Chapter 4.1.1.21.3)

Should the CPA proposed action occur, there would be only minor economic changes in the Texas, Louisiana, Mississippi, Alabama, and Florida EIA's. This is because the demand would be met primarily with the existing population and labor force. The CPA proposed action is expected to generate less than a 1 percent increase in employment in any of these subareas. Most of the employment related to the CPA proposed action is expected to occur in Texas (EIA TX-3) and Louisiana (EIA's LA-2, LA-3, and LA-4).

The short-term social and economic consequences for the Gulf coastal region should a spill ≥1,000 bbl occur includes the opportunity cost of employment and expenditures that could have gone to production or consumption rather the spill cleanup efforts. Nonmarket effects such as traffic congestion, strains on public services, shortages of commodities or services, and disruptions to the normal patterns of activities or expectations are also expected to occur in the short term. These negative, short-term social and economic consequences of a spill are expected to be modest in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Negative, long-term economic and social impacts may be more substantial if fishing, shrimping, oystering, and/or tourism were to suffer or were to be perceived as having suffered because of the spill or if there were substantial changes to the energy industries in the region as a result of the spill. Net employment impacts from a spill are not expected to exceed 1 percent of baseline employment for any EIA in any given year even if they are included with employment associated with routine oil and gas development activities associated with the CPA proposed action.

Environmental Justice (Chapter 4.1.1.21.4)

Because of the existing extensive and widespread support system for OCS-related industry and associated labor force, the effects of the CPA proposed action are expected to be widely distributed and to have little impact. This is because the proposed action is not expected to significantly change most of the existing conditions such as traffic or the amount of infrastructure. In general, who would be hired and where new infrastructure might be located is impossible to predict but, in any case, it would be very limited. Because of Louisiana's extensive oil-related support system, that State is likely to experience more employment effects related to the CPA proposed action than are the other coastal states, and because of the concentration of this system in Lafourche Parish, that parish is likely to experience the greatest benefits from employment benefits and burdens from traffic and infrastructure demand. Similarly, impacts related to the CPA proposed action are expected to be economic and to have a limited but positive effect on low-income and minority populations, particularly in Louisiana and Lafourche Parish. However, given the low levels of expected effects and given the existing distribution of the industry and the limited concentrations of minority and low-income peoples, the CPA proposed action is not expected to have a disproportionate effect on these populations even in Lafourche Parish.

Future changes in activity levels would most likely be caused by fluctuations in oil prices and imports, and not by activities related to the proposed action. The CPA proposed action is not expected to have disproportionate high/adverse environmental or health effects on minority or low-income people.

Chemical and drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Low-income and minority populations might be more sensitive to oil spills in coastal waters than is the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with purchased ones, and their likelihood of participating in cleanup efforts and other mitigating activities. With the exception of a catastrophic accidental event, such as the DWH event, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area.

An event like the DWH event could have adverse and disproportionate effects for low-income and minority communities in the analysis area. Many of the long-term impacts of the DWH event to low-income and minority communities are unknown. While economic impacts have been partially mitigated by employers retaining employees for delayed maintenance or through the Gulf Coast Claims Facility Program's emergency funds, the physical and mental health effects to both children and adults within these communities could potentially unfold for many years. As studies of past oil spills have highlighted, different cultural groups can possess varying capacities to cope with these types of events. Likewise, some low-income and/or minority groups may be more reliant on natural resources and/or less equipped to substitute contaminated or inaccessible natural resources with private market offerings. Because lower-income and/or minority communities may live near and directly involved with spill cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health affects. To date, there have been no longitudinal epidemiological studies of possible long-term health effects for oil-spill cleanup workers. The post-DWH event human environment remains dynamic, and BOEMRE will continue to monitor these populations over time and to document short- and long-term DWH event impacts. In the future, the long-term impacts of the DWH event will be clearer as time allows the production of peer-reviewed research and targeted studies that determine those impacts.

The DWH event was a low-probability, high-impact catastrophic event. For the reasons set forth in the analysis above, the kinds of accidental events (smaller, shorter time scale) that are likely to result from the CPA proposed action may affect low-income and/or minority more than the general population, at least in the shorter term. These higher risk groups may lack the financial or social resources and may be more sensitive and less equipped to cope with the disruption these events pose. These smaller events, however, are not likely to significantly affect minority and low-income communities in the long term.

Additional Resources Considered due to the *Deepwater Horizon* Event (Chapter 4.1.1.22)

Soft Bottoms (Chapter 4.1.1.22.1)

Although localized impacts to comparatively small areas of the soft-bottom benthic habitats would occur, the routine impacts of the proposed action would be on a relatively small area of the seafloor compared with the overall area of the seafloor of the CPA (268,922 km^2; 103,831 mi^2). The greatest impact is the alteration of benthic communities as a result of smothering, chemical toxicity, and substrate change. Communities that are smothered by cuttings repopulate, and populations that are eliminated as a result of sediment toxicity or organic enrichment would be taken over by more tolerant species. The community alterations are not so much the introduction of a new benthic community as a shift in species dominance. These localized impacts generally occur within a few hundred meters of platforms, and the greatest impacts are seen close to the platform. These patchy habitats within the Gulf of Mexico are probably not very different from the early successional communities that predominate throughout areas of the Gulf of Mexico that are frequently disturbed.

Only a very small portion of the seafloor of the Gulf of Mexico would experience lethal impacts as a result of blowouts, surface, and subsurface oil spills and the associated effects. This is because of the small amount of proportional space that OCS activities occupy on the seafloor. The greatest impacts would be closest to the spill, and impacts would decrease with distance from the spill. Contact with spilled oil at a distance from the spill would likely cause sublethal to immeasurable effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. Oil from a subsurface spill that reaches benthic communities would be primarily sublethal and impacts would be at the local community level. Any sedimentation and sedimented oil would also be at low concentrations by

the time it reaches benthic communities far from the location of the spill, also resulting in sublethal impacts. Also, any local communities that are lost would be repopulated fairly rapidly. Although an oil spill may have some detrimental impacts, especially closest to the occurrence of the spill, the impacts may be no greater than natural biological fluctuations, and impacts would be to an extremely small portion of the overall Gulf of Mexico.

Diamondback Terrapins (Chapter 4.1.1.22.2)

Routine activities resulting from the CPA proposed action is possible but unlikely. Because of the greatly improved handling of waste and trash by industry and the annual awareness training required by the marine debris mitigations, the plastics in the ocean are decreasing and the devastating effects on offshore and coastal marine life are being minimized. The routine activities of the CPA proposed action are unlikely to have significant adverse effects on the size and recovery of any terrapin species or population in the GOM.

Habitat destruction, road construction, and drowning in crab traps are the most recent threats to diamondback terrapins. In the 1800's, populations declined due to overharvesting for meat. Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to a catastrophic spill and response efforts could drastically affect future population levels and reproduction. However, there is not expected to be a significant increase to infrastructure, and the probability of a spill large enough to impact the diamondback terrapins or their habitat is low with the CPA proposed action.

No substantial information was found at this time that would alter the overall conclusion that accidental impacts on diamondback terrapins associated with the CPA proposed action would be minimal.

2.3.1.3. Mitigating Measures

The following eight environmental and military mitigations, referred to as lease stipulations, were included for analysis in the Chapter 2.4.1.3 of the Multisale EIS and in Chapter 2.2.1.3.of the 2009-2012 Supplemental EIS. Any stipulations or mitigation requirements to be included in the lease sale will be described in detail in the Final NOS. Stipulations or mitigation requirements in addition to the those analyzed in this Supplemental EIS can also be developed and applied, and will also be described in detail in the Final NOS.

2.3.1.3.1. Topographic Features Stipulation

The Topographic Features Stipulation protects the biota of the topographic features from adverse effects due to routine oil and gas activities, including physical damage from anchoring and rig emplacement and the potential toxic and smothering effects from muds and cuttings discharges. The Topographic Features Stipulation has been included in leases since 1973 and has effectively prevented damage to the biota of these banks from routine oil and gas activities such as anchoring. Monitoring studies have demonstrated that the shunting requirements of the stipulation are effective in preventing the drilling mud and cuttings from impacting the biota of the banks. The topographic highs on and near these blocks are often associated with salt domes, which are attractive areas for hydrocarbon exploration. Instead, blocks on the topographic features have been offered for lease with a stipulation that has proven effective in protecting sensitive biological resources. The location of the blocks affected by the Topographic Features Stipulation is shown on **Figure 2-1**.

2.3.1.3.2. Live Bottoms (Pinnacle Trend and Low Relief) Stipulation

The Live Bottom (Pinnacle Trend) Stipulation covers a small portion of the northeastern CPA lease sale area that is characterized by a pinnacle trend, which is classified as a live bottom under the stipulation. The Live Bottom (Low Relief) Stipulation defines low-relief areas as seagrass communities, areas that contain biological assemblages consisting of sessile invertebrates living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where a hard substrate and vertical relief may favor the accumulation of turtles, fish, or other fauna. This Agency developed the stipulation to protect biological resources in the Pinnacle Trend and low relief in

response to concerns that disturbing any of the series of topographic irregularities might adversely affect biological communities that have developed on the surfaces of the features and affect the habitat they provide for pelagic fishes. The stipulation requires avoidance of the features during the placement of oil and gas structures and the laying of pipelines. The stipulation has been adopted in CPA lease sales since 1990 and has been effective in protecting the features and resident biological communities from damage. The location of the blocks affected by the Live Bottom (Pinnacle Trend and Low Relief) Stipulation is shown on **Figure 2-1**.

2.3.1.3.3. Military Areas Stipulation

The Military Areas Stipulation has been applied to all blocks leased in military areas since 1977 and reduces potential impacts, particularly in regards to safety; but it does not reduce or eliminate the actual physical presence of oil and gas operations in areas where military operations are conducted. The stipulation contains a “hold harmless” clause (holding the U.S. Government harmless in case of an accident involving military operations) and requires lessees to coordinate their activities with appropriate local military contacts. **Figure 2-3** shows the military warning areas in the Gulf of Mexico.

2.3.1.3.4. Evacuation Stipulation

The Evacuation Stipulation would apply to any lease in the easternmost portion of the CPA lease sale area. This stipulation was developed in consultation with the U.S. Department of Defense (DOD) to address specific potential use conflict issues between oil and gas operations and military operations in the GOM. An evacuation stipulation has been applied to all blocks leased in this area since 2001. This stipulation would provide for the evacuation of personnel and the shut-in of operations during any events conducted by the military that could pose a danger to ongoing oil and gas operations. It is expected that these measures would serve to eliminate dangerous conflicts between oil and gas operations and military operations.

2.3.1.3.5. Coordination Stipulation

The Coordination Stipulation would apply to any lease in the easternmost portion of the CPA lease sale area. This stipulation was developed in consultation with DOD to address specific potential use conflict issues between oil and gas operations and military operations in the GOM. A coordination stipulation has been applied to all blocks leased in this area since 2001. This stipulation would provide for the review of pending oil and gas operations by military authorities and could result in delaying oil and gas operations if military activities have been scheduled in the area that may put oil and gas operations, equipment, and personnel at risk.

2.3.1.3.6. Blocks South of Baldwin County, Alabama, Stipulation

The Blocks South of Baldwin County, Alabama, Coast Stipulation would be included only on leases south of and within 15 mi (24 km) of Baldwin County, Alabama (**Figure 2-1**). For several years, the Governor of Alabama has continually indicated opposition to new leasing south and within 15 mi (24 km) of Baldwin County but has requested that, if the area is offered for lease, a lease stipulation to reduce the potential for visual impacts be applied to all new leases in this area. Prior to the decision in 1999 on the Final Notice of Sale for Sale 172, the Gulf of Mexico OCS Regional Director, in consultation with the Geological Survey of Alabama/State Oil and Gas Board, developed a lease stipulation to be applied to any new leases within the 15-mi (24-km) area to mitigate potential visual impacts. The stipulation specifies requirements for consultation that lessees must follow when developing plans for fixed structures. The stipulation has been continually adopted in annual CPA lease sales since 1999.

2.3.1.3.7. Protected Species Stipulation

The Protected Species Stipulation has been applied to all blocks leased in the GOM since December 2001. This stipulation was developed in consultation with the Department of Commerce, NOAA, NMFS,

and the Department of the Interior, FWS in accordance with Section 7 of the ESA and is designed to minimize or avoid potential adverse impacts to federally protected species.

2.3.1.3.8. Law of the Sea Convention Royalty Payment Stipulation

The Law of the Sea Convention Royalty Payment Stipulation applies to blocks or portions of blocks beyond the U.S. Exclusive Economic Zone (generally greater than 200 nmi [230 mi; 370 km] from the U.S. coastline). Leases on these blocks may be subject to special royalty payments under the provisions of the 1982 Law of the Sea Convention (consistent with Article 82), if the U.S. becomes a party to the Convention prior to or during the life of the lease.

2.3.2. Alternative B—The Proposed Action Excluding the Unleased Blocks Near the Biologically Sensitive Topographic Features

2.3.2.1. Description

Alternative B differs from Alternative A by not offering the blocks that are possibly affected by the proposed Topographic Features Stipulation (**Chapter 2.3.1.3.1** and **Figure 2-1)**. All of the assumptions (including the seven other potential mitigating measures) and estimates are the same as for Alternative A. A description of Alternative A is presented in **Chapter 2.3.1.1**.

2.3.2.2. Summary of Impacts

The analyses of impacts summarized in **Chapter 2.3.1.2** and described in detail in **Chapter 4** are based on the development scenario, which is a set of assumptions and estimates on the amounts, locations, and timing for OCS exploration, development, and production operations and facilities, both offshore and onshore. A detailed discussion of the development scenario and major related impact-producing factors is included in **Chapter 3**.

The difference between the potential impacts described for Alternative A and those under Alternative B is that under Alternative B no oil and gas activity would take place in the blocks subject to the Topographic Features Stipulation (**Figure 2-1**). The number of blocks that would not be offered under Alternative B represents only a small percentage of the total number of blocks to be offered under Alternative A; therefore, it is assumed that the levels of activity for Alternative B would be essentially the same as those projected for the proposed action. As a result, the impacts expected to result from Alternative B would be very similar to those described under the proposed action (**Chapter 4**). Therefore, the regional impact levels for all resources, except for the topographic features, would be similar to those described under the proposed action. This alternative, if adopted, would prevent any oil and gas activity whatsoever in the affected blocks; thus, it would eliminate any potential direct impacts to the biota of those blocks from oil and gas activities, which otherwise would be conducted within the blocks.

2.3.3. Alternative C—The Proposed Action Excluding the Unleased Blocks within 15 Miles of the Baldwin County, Alabama, Coast

2.3.3.1. Description

Alternative C differs from Alternative A by not offering any unleased blocks within 15 mi (24 km) of the Baldwin County, Alabama, coast. All of the assumptions (including the seven other potential mitigating measures) and estimates are the same as for Alternative A (**Chapters 2.3.1.3 and 4.1**). A description of Alternative A is presented in **Chapter 2.3.1.1**. The coastal region adjacent to the area considered under Alternative C is designated as EIA AL-1 (**Figure 2-2**).

2.3.3.2. Summary of Impacts

The analyses of impacts summarized in **Chapter 2.3.1.2** and described in detail in **Chapter 4.1** are based on the development scenario, which is a set of assumptions and estimates on the amounts,

locations, and timing for OCS exploration, development, and production operations and facilities, both offshore and onshore. A detailed discussion of the development scenario and major related impact-producing factors is included in **Chapter 3**.

The difference between the potential impacts described for Alternative A and those under Alternative C is that under Alternative C no oil and gas activity would take place in blocks within 15 mi (24 km) of the Baldwin County coast (**Figure 2-1**). The assumption that the levels of activity for Alternative C are essentially the same as those projected for the proposed action leads to the conclusion that the impacts expected to result from Alternative C would be very similar to those described under the proposed action (**Chapter 4**). Therefore, the regional impact levels for all resources, except the visual impact from recreational beaches, would be similar to those described under the proposed action. This alternative, if adopted, would reduce the potential aesthetic impacts to recreational beaches along the Baldwin County coast.

2.3.4. Alternative D—No Action

2.3.4.1. Description

Alternative D is the cancellation of the proposed CPA lease sale. The opportunity for development of the estimated 0.801-1.624 BBO and 3.332-6.560 Tcf of gas that could have resulted from the proposed lease sale would be precluded or postponed. Any potential environmental impacts resulting from the proposed lease sale would not occur or would be postponed.

2.3.4.2. Summary of Impacts

Canceling the lease sale would eliminate the effects described for Alternative A (**Chapter 4.1**). The incremental contribution of the proposed lease sale to cumulative effects would also be avoided, but effects from other activities, including other OCS lease sales, would remain.

If the lease sale would be canceled, the resulting development of oil and gas would most likely be postponed to a future sale; therefore, the overall level of OCS activity in the CPA would only be reduced by a small percentage, if any. Therefore, the cancellation of the proposed lease sale would not significantly change the environmental impacts of overall OCS activity. However, the cancellation of the lease sale may result in direct economic impacts to the individual companies. Revenues collected by the Federal Government (and thus revenue disbursements to the States) would be adversely affected also.

Other sources of energy may substitute for the lost production. Principal substitutes would be additional imports, conservation, additional domestic production, and switching to other fuels. These alternatives, except conservation, have significant negative environmental impacts of their own.

CHAPTER 3

IMPACT-PRODUCING FACTORS AND SCENARIO

3. IMPACT-PRODUCING FACTORS AND SCENARIO

In order to describe the level of activity that could reasonably result from the proposed action (i.e., proposed lease sale), BOEMRE developed exploration and development activity scenarios. These scenarios provide a framework for analyses of potential environmental and socioeconomic impacts of the proposed lease sale that could potentially affect the biological, physical, and socioeconomic resources of the Gulf of Mexico. The offshore and coastal impact-producing factors and scenario can be found in Chapters 4.1.1 and 4.1.2 of the Multisale EIS, respectively, and in Chapters 3.1.1 and 3.1.2 of the 2009-2012 Supplemental EIS, respectively. The following is a summary of offshore and coastal impact-producing factors with activity scenarios from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The potential impacts of the offshore and coastal activities associated with proposed CPA Lease Sale 216/222 are considered in the environmental analysis sections in **Chapter 4**.

3.1. IMPACT-PRODUCING FACTORS AND SCENARIO—ROUTINE OPERATIONS

3.1.1. Offshore Impact-Producing Factors and Scenario

Chapter 4.1.1 of the Multisale EIS and Chapter 3.1.1 of the 2009-2012 Supplemental EIS describe the infrastructure and activities (impact-producing factors) that would occur offshore as a result of a proposed action. Those discussions are incorporated by reference.

Offshore is defined here as the OCS portion of the GOM that begins 10 mi (16 km) offshore Florida; 3 nmi (3 mi; 6 km) offshore Louisiana, Mississippi, and Alabama; it extends seaward to the limits of the U.S. Exclusive Economic Zone (**Figure 1-1**). The projections used to develop the offshore proposed action scenarios are based on resource estimates as summarized in the *Planning Area Resources Addendum to Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf, 2006* (USDOI, MMS, 2006a), current industry information, and historical trends.

The proposed action scenarios are based on the following factors:

- recent trends in the amount and location of leasing, exploration, and development activity;
- estimates of undiscovered, unleased, conventionally recoverable oil and gas resources in the planning area;
- existing offshore and onshore oil and/or gas infrastructure;
- industry information; and
- oil and gas technologies, and the economic considerations and environmental constraints of these technologies.

In order to present the best reasonable projections possible, BOEMRE continually updates models and formulas used to develop these scenarios. The experience of subject matter experts is incorporated into this process, along with the latest industry trends and historical data.

The proposed lease sale is represented by bounded ranges for resource estimates, projected exploration and development activities, and impact-producing factors. The proposed lease sale is expected to be within the scenario ranges. The scenarios used in this Supplemental EIS represent the best assumptions and estimates of a set of future conditions that are considered reasonably foreseeable after the DWH event and suitable for presale impact analyses. These scenarios do not represent a BOEMRE recommendation, preference, or endorsement of any level of leasing or offshore operations, or of the types, numbers, and/or locations of any onshore operations or facilities.

Analysis Period

The BOEMRE assumes fields discovered as a result of a proposed action will reach the end of their economic life within 40 years of the lease sale. Activity levels are not projected beyond 40 years. This is based on averages for time required for exploration, development, production life, and decommissioning for leases in the GOM.

Deepwater Horizon Event

This Supplemental EIS is being prepared because of the potential changes to baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of (1) the DWH event between April 20 and July 15, 2010 (the period when oil flowed from the Macondo well in Mississippi Canyon Block 252 [**Figure 1-2**]); (2) the acute impacts that have been reported or surveyed since that time; and (3) any new information that may be available. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments.

The BOEMRE, Gulf of Mexico OCS Region, Resource and Evaluation Office's Modeling and Forecasting Team has reevaluated the exploration and development activity scenario for a CPA proposed action because of the DWH event.

Resource Estimate and Timetables

The resource estimates for a proposed action are based on two factors: (1) the conditional estimates of undiscovered, unleased, conventionally recoverable oil and gas resources in the proposed lease sale areas; and (2) the estimates of the portion or percentage of these resources assumed to be leased, discovered, developed, and produced as a result of a proposed action. The estimates of undiscovered, unleased, conventionally recoverable oil and gas resources are based upon a comprehensive appraisal of the conventionally recoverable petroleum resources of the Nation as of January 1, 2003. Because of the inherent uncertainties associated with an assessment of undiscovered resources, techniques were employed and the results were reported as a range of values corresponding to different probabilities of occurrence.

A summarized discussion of the methodologies employed and the results obtained in the assessment are presented in this Agency's brochure entitled, *Planning Area Resources Addendum to Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf, 2006* (USDOI, MMS, 2006a). The estimates of the portion of the resources projected to be leased, discovered, developed, and produced as a result of a proposed action are based upon logical sequences of events that incorporate past experience, current conditions, and foreseeable development strategies. A wealth of historical databases and information derived from oil and gas exploration and development activities are available to BOEMRE and were used extensively. The undiscovered, unleased, conventionally recoverable resource estimates for a proposed action are expressed as ranges, from low to high. This range provides a reasonable expectation of oil and gas production anticipated from typical lease sales held as a result of the proposed actions based on an actual range of historic observations.

Table 3-1 presents the projected ranges for oil and gas production resulting from the proposed CPA lease sale. Major impact-producing factors, including the number of exploration and delineation wells, production platforms, and development wells projected to develop and produce the estimated resources for the CPA proposed action, are given in **Table 3-2**. **Table 3-2** shows the distribution of these factors by offshore subareas in the proposed lease sale area. The proposed lease sale area was divided into offshore subareas based upon water-depth range (**Figure 3-1**) that reflect the technological requirements and related physical and economic impacts.

For purposes of analysis, the life of the leases resulting from the proposed action is assumed to not exceed 40 years because, historically, the entire life of a well from beginning to end is encompassed within a 40-year period. Following the proposed action (lease sale), areawide exploratory drilling activity would take place over an 8-year period, beginning within 1 year after the lease sale. Final decommissioning and removal activities occur from the 15th year to the 40th year.

Activity as the result of a lease sale is assumed to be staggered over time. A recently published Agency study estimated physical and economic performance measures to characterize lease sales and development in the GOM (Iledare and Kaiser, 2007). It was used to further refine the scenario presented in the Multisale EIS. The average lag of exploration and production from leases issued from 1983 to 1999 increased by water depth and decreased over time as shown in the Tables 3-4 and 3-5 in the 2009-2012 Supplemental EIS. Because of variation by water depth, exploration and production activity is staggered over time, taking on average 1.9-4.5 years after a lease sale before exploration begins and 3.4-8.3 years before first production.

3.1.1.1. Exploration and Delineation

Chapter 4.1.1.2.2 of the Multisale EIS and Chapter 3.1.1.1 of the 2009-2012 Supplemental EIS describe the impacting factors arising from exploration and delineation drilling in the GOM resulting from a proposed action in the CPA. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and the 2009-2012 Supplemental EIS.

3.1.1.1.1. Seismic Surveying Operations

Prelease surveys are comprised of seismic work performed on or off leased areas, focused most commonly (but not always) on deeper targets and collectively authorized under BOEMRE's geological and geophysical permitting process. Postlease, high-resolution seismic surveys collect data on surficial geology used to identify potential shallow geologic hazards for engineering and site planning for bottom-founded structures. They are also used to identify environmental resources such as chemosynthetic community habitat, gas hydrates, and archaeological resources. High-resolution surveys are conducted as authorized under the terms and conditions of the lease agreement. Other postlease surveys include downhole seismic surveying (vertical seismic profiling [VSP]) and time-lapse, deep-focused, 3D surveying (4D surveys) used for reservoir monitoring.

All seismic surveying constitutes a type of remote sensing. Typical prelease seismic surveying operations for exploring deep geologic formations typically are two- or three-dimensional (2D or 3D) surveys. A tow vessel pulls an array of airguns and streamers (acoustic receiver cable) behind the vessel 5-10 m (16-33 ft) below the sea surface. The airgun array produces underwater sound by releasing compressed air into the water column, creating an acoustical energy pulse the echoes of which are detected by hydrophones towed on streamers behind the vessel. Streamer arrays are 3-8 mi (5-12 km) or greater in length, depending on survey specifications. Tow vessel speed is typically 3-5 knots (kn) (about 4-6 miles per hour [mph]) with gear deployed.

The 3D surveys carried out by seismic vendors can consist of a few to several hundred OCS blocks. Multiple source and multiple-streamer technologies are often used for 3D seismic surveys. For a typical 3D survey, air in a closed chamber of the air gun is quickly discharged through a port, creating a pressure pulse and air bubble in the water. To release more energy into the pressure pulse and to offset the deleterious effects of bubble oscillations on the pressure pulse, multiple airguns with various chamber sizes are used. These individual airgun chamber sizes vary from 20 to 380 in^3 (327 to 6,227 cm^3). In some cases, two or three airguns are placed in a cluster to increase the effective chamber size. The individual airguns are suspended in the water from a float system referred to as a sub-array. Each sub-array contains six or seven individual airguns spaced from 2.5 to 3 m (7.5 to 10 ft) apart, making the total sub-array length 14-17 m (46-56 ft) long. Typically, three (sometimes four) sub-arrays are combined to form an array. When three sub-array elements are used, the spacing is 8 m (26 ft) between sub-arrays; when four sub-arrays are used, the spacing is 12 m (39 ft). Thus, the overall width of the array is generally 16-36 m (52-118 ft). The array is towed at a depth of 5-7 m (16-23 ft).

A 4D or time-lapse survey is used to monitor reservoir production to optimize the amount of hydrocarbon recovered. These surveys consist of a series of 3D surveys collected over time under the same acquisition and receiving parameters.

Vertical seismic profiling (VSP) is usually done by placing a receiver down a wellbore at different depths and with an external acoustic source near the wellbore (zero-offset VSP) or on a vessel at different distances from the wellbore (a walk-away VSP). These surveys are used to obtain information about the nature of the seismic signal, as well as more information about the geology surrounding the vertical array of sensors. The VSP data can be cross-correlated with ship-towed seismic survey datasets to refine

identification of lithologic changes and the content of formation fluids. Zero offset and walk-away VSP surveys are the most common VSP surveys conducted in the GOM.

Ocean-Bottom Surveys

Ocean-bottom cable surveys were originally designed to enable seismic surveys in congested areas, such as producing fields, with their many platforms and producing facilities. Autonomous nodes, deployed and retrieved by either cable or ROV's, are now used as an alternative to cables. The ocean-bottom cable surveys have been found to be useful for obtaining multicomponent (i.e., seismic pressure, vertical, and the two horizontal motions of the water bottom, or seafloor) information.

The ocean-bottom cable surveys and nodal acquisition require the use of multiple ships (i.e., usually two ships for cable or node layout/pickup, one ship for recording, one ship for shooting, and two utility boats). These ships are generally smaller than those used in streamer operations, and the utility boats can be very small. Operations are conducted "around the clock" and begin by dropping the cables off the back of the layout boat or by deployment of the nodal receivers by ROV's. Cable length or the numbers of nodes depend upon the survey demands; it is typically 2.6 mi (4.2 km) but can be up to 7.5 mi (12 km). However, depending on spacing and surveys size, hundreds of nodes can be deployed and re-deployed over the span of the survey. Groups of seismic detectors, usually hydrophones and vertical motion geophones, are attached to the cable in intervals of 82-164 ft (25-50 m) or autonomous nodes are spaced similarly. Multiple cables/nodes are laid parallel to each other using this layout method, with a 164-ft (50-m) interval between cables/nodes. Typically, dual airgun arrays are used on a single source vessel. When the cable/node is in place, a ship towing an airgun array (which is the same airgun array used for streamer work) passes between the cables/ nodes, firing every 82 ft (25 m). Sometimes a faster source ship speed of 7 mph (6 kn), instead of the normal speed of 5.2 mph (4.5 kn), is used with a decrease in time between gun firings. After a source line is shot, the source ship takes about 10-15 minutes to turn around and pass down between the next two cables or line of nodes. When a cable/node is no longer needed to record seismic data, it is picked up by the cable pickup ship and is moved over to the next position where it is needed. The nodes are retrieved by an ROV. A particular cable/node can lay on the bottom anywhere from 2 hours to several days, depending on operation conditions. Normally, a cable will be left in place about 24 hours. However, nodes may remain in place until the survey is completed or recovered and then re-deployed by an ROV.

Location of the cables/nodes on the bottom is done by acoustic pingers located at the detector groups and by using the time of first arrival of the seismic pulse at the detector group. A detector group is a node or group of nodes that enable the seismic ship to accurately determine node location. To obtain more accurate first arrival times, the seismic data are recorded with less electronic filtering than is normally used. This detailed location is combined with normal global positioning system (GPS) navigational data collected on the source ship. In deep water, the process of accurately locating bottom cables/nodes is more difficult because of the effects of irregular water bottoms and the thermal layers, which affect travel times and travel paths, thus causing positioning errors.

As part of the environment impact analysis required with the EP, DOCD, or DPP, 30 CFR 250.227(b)(6) and 30 CFR 250.261(b)(6) require the applicant to submit archaeological information. In certain circumstances, the Regional Director may require the preparation of an archaeological report to accompany the EP, DOCD, or DPP, under 30 CFR 250.194. The requirements for archaeological reports are clarified in NTL 2005-G07, "Archaeological Resource Surveys and Reports." If the archaeological report required under 30 CFR 250.194 indicates that an archaeological resource may be present, the lessee must either locate the site of any operation so as not to adversely affect the area where the archaeological resource may be, demonstrate that an archaeological resource does not exist, or demonstrate that archaeological resources will not be adversely affected by operations. If the lessee discovers any archaeological resource while conducting approved operations, operations must be immediately stopped and the discovery reported to the BOEMRE Regional Supervisor, Office of Leasing and Environment, within 48 hours of its discovery.

CPA Proposed Action Scenario: The repetitive, cyclical nature of seismic surveys can afford potential lessees with a prelease seismic survey attributable to lease sales held up to 7-9 years after the acquisition of that survey. This area may or may not be resurveyed based on new technology, subsurface geological trends, or production from other reservoirs. The BOEMRE projects that the CPA proposed

action would result in 1,500-2,500 mi (2,400-4,000 km) of 2D deep seismic and 1,500-2,000 OCS blocks surveyed annually by 3D deep seismic. For postlease seismic surveys, BOEMRE projects the CPA proposed action would result in about 3-6 VSP operations and about 3,000-4,000 miles (4,828-6,437 km) surveyed by high-resolution seismic during the life of the proposed action.

OCS Program Scenario: Seismic surveys are projected to follow the trends of exploration activities until 2027 and to remain relatively steady throughout the second half of the 40-year analysis period. During the first 2-4 years of the analysis period, BOEMRE projects that annually there would be 5-10 VSP operations, 12,500-16,500 lines miles (20,117-24.945 km) surveyed by high-resolution seismic, 8,000-10,000 mi (12,900-16,000 km) of 2D deep seismic, and 2,500-3,000 OCS blocks surveyed by 3D deep seismic. During the second half of the analysis period, it is projected that annually there would be 510 VSP operations, 6,200-8,300 mi (9,978-13,356 km) surveyed by high-resolution seismic, 6,000-8,000 mi (9,650-12,900 km) of 2D deep seismic, and 1,500-2,500 OCS blocks surveyed by 3D deep seismic, reflecting continuous improvement of data acquisition (or other future technology that may replace this).

3.1.1.1.2. Exploration and Delineation Drilling

Oil and gas operators use drilling terms that represent stages in the discovery and exploitation of hydrocarbon resources. An exploration well generally refers to the first well drilled on a prospective geologic structure to confirm that a resource exists and to validate how much resource can be expected. If a resource is discovered in quantities appearing to be economically viable, one or more follow-up delineation wells help define the amount of resource or the extent of the reservoir. Following a discovery, an operator will often temporarily plug and abandon a discovery to allow time for a development scenario to be generated and for equipment to be built or procured.

In the GOM, exploration and delineation wells are typically drilled with MODU's; e.g., jack-up rigs, semisubmersible rigs, submersible, platform rigs, or drill ships. Non-MODU drilling units, such as inland barges, are also used. The type of rig chosen to drill a prospect depends primarily on water depth. Because the water-depth ranges for each type of drilling rig overlap to a degree, other factors such as availability and daily rates play a large role when an operator decides upon the type of rig to contract. The depth ranges for exploration rigs used in this analysis for Gulf of Mexico MODU's are indicated below.

MODU or Drilling Rig Type	Water Depth Range
Jack-up, submersible, and inland barges	≤100 m
Semisubmersible and platform rig	100-3,000 m
Drillship	≥600 m

Table 3-3 shows GOM deepwater rig counts and average day rates for contracting the typical rig types used for OCS exploration, although some operators have discounted prices for multiyear contracts. The scenarios for the proposed actions presented in the Multisale EIS assumed that an average exploration/delineation well will require 30-45 days to drill. The actual time required for each well depends on a variety of factors, including the depth below mudline of the prospect's potential target zone, the complexity of the well design, and the directional offset of the wellbore needed to reach a particular zone.

The cost of an ultra-deepwater well (>6,000 ft; >1,829 m water depth) can be $30-$50 million or more, without certainty that objectives can be reached or if the objective ultimately produces hydrocarbon. Some recent ultra-deepwater exploration wells in the GOM have been reported to have cost upwards of $100 million. The BOEMRE regulations require that operators conduct their offshore operations in a safe manner. Subpart D of BOEMRE's regulations (30 CFR 250) specifies requirements for drilling activities. See **Chapter 1.3.1** and **Table 1-1**, which provide a summary of new safety requirements.

Exploration Plans

The regulation at 30 CFR 250 Subpart B specifies the requirements for the exploration plans (EP's) that operators must submit to BOEMRE for approval prior to deploying an exploration program. An EP must be submitted to BOEMRE for review and decision before any exploration activities, except for preliminary activities, can begin on a lease. The EP describes exploration activities, drilling rig or vessel, proposed drilling and well-testing operations, environmental monitoring plans, oil-spill response plans, and other relevant information, and it includes a proposed schedule of the exploration activities. Guidelines and environmental information requirements for lessees and operators submitting an EP are addressed in 30 CFR 250.211 and are further explained in NTL 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS" and NTL 2009-G27, "Submitting Exploration Plans and Development Operations Coordination Documents." The requirements for archaeological and shallow hazard surveys and their reports are clarified in NTL 2005-G07, "Archaeological Resource Surveys and Reports" and NTL 2008-G05, "Shallow Hazards Program."

In addition, the regulations at 30 CFR 250.227(b)(6) and 30 CFR 250.261(b)(6) require the lessee to include an archaeological report with an EP or DOCD. If the evidence suggests that an archaeological resource may be present, the lessee must either locate the site of any operation so as not to adversely affect the area where the archaeological resource may be, demonstrate that an archaeological resource does not exist, or demonstrate that archaeological resources will not be adversely affected by operations. If the lessee discovers any archaeological resource while conducting approved operations, operations must be immediately stopped and the discovery reported to the BOEMRE Regional Supervisor, Office of Leasing and Environment, within 48 hours of its discovery.

Historically, drilling rig availability has been a limiting factor for activity in the Gulf and is assumed to be a limiting factor for activity projected as a result of the proposed lease sale. A search on the Rigzone website in December 2010 (Rigzone, 2010) showed that operators in the GOM currently had commitments for the following rig classes: 83 jack-ups; 25 semisubmersibles; 6 submersibles; 60 inland barges; and 10 drillships. Operators had a rig utilization rate of about 68 percent, which means that approximately 68 percent of the rigs in the GOM available for contract are contracted and operating. The Rigzone website indicates the total worldwide deployment capability for the various rig classes is 523 jack-ups, 222 semisubmersibles, 6 submersibles, 76 inland barges, and 91 drillships.

Table 3-2 shows the estimated range of exploration and delineation wells by water depth subarea for the CPA proposed action.

CPA Proposed Action Scenario: The BOEMRE estimates that 65-121 exploration and delineation wells would be drilled as a result of the CPA proposed action. **Table 3-2** shows the estimated range of exploration and delineation wells by water-depth range. Approximately 31-40 percent of the projected wells are expected to be on the continental shelf (0-200 m [0-656 ft] water depth) and 60-69 percent are expected in the intermediate water-depth ranges and deeper (>200 m; 656 ft).

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. The BOEMRE estimates that 5,010-6,569 exploration and delineation wells would be drilled in the CPA as a result of the OCS Program. Tables 4-4, 4-5, and 4-6 of the Multisale EIS show the estimated range of exploration and delineation wells by water-depth range. Of these wells, 69-71 percent are expected to be on the continental shelf (0-200 m [0-656 ft] water depth) and 29-31 percent are expected in intermediate water-depth ranges and deeper (>200 m; 656 ft).

3.1.1.2. Development and Production

Chapter 4.1.1.3 of the Multisale EIS and Chapter 3.1.1.2 of the 2009-2012 Supplemental EIS describe impacting factors arising from development and production drilling activity in the GOM. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and the 2009-2012 Supplemental EIS.

3.1.1.2.1. Development and Production Drilling

Delineation and production wells are sometimes collectively termed development wells. Development wells may be drilled from movable structures, such as jack-up rigs, fixed bottom-supported

structures, floating vertically moored structures, floating production facilities, and drillships (either anchored or dynamically positioned drilling vessels). The type of production structure installed at a site depends mainly on water depth, but the total facility lifecycle, the type and quantity of hydrocarbon production expected, the number of wells to be drilled and produced, and the number of anticipated tiebacks from other fields can also influence an operator's development facility procurement decision. The number of wells per structure varies according to the type of production structure used, the prospect size, and the drilling/production strategy deployed for the drilling program and for resource conservation. Production systems can be fixed, floating, or subsea, which has shown an increasing trend in deep water.

This Agency has described and characterized production structures in its deepwater reference document (Regg et al., 2000) and descriptions are summarized in Chapter 3.3.5.7.1 of the Multisale EIS and in Chapter 3.1.1.2.2.1 of the 2009-2012 Supplemental EIS. In water depths up to 400 m (1,312 ft), the scenarios assume that conventional, fixed platforms that are rigidly attached to the seafloor will be the type of structure preferred by operators. In water depths of <200 m (656 ft), 20 percent of the platforms are expected to be manned (defined as having sleeping quarters on the structure). In depths between 200 and 400 m (656 and 1,312 ft), all structures are assumed to be manned. It is also assumed that helipads will be located on 66 percent of the structures in water depths <60 m (197 ft), on 94 percent of the structures in water depths between 60 and 200 m (656 ft), and on 100 percent of the structures in water depths >200 m (656 ft). At water depths >400 m (1,312 ft), platform designs based on rigid attachment to the seafloor are not expected to be used. The 400-m (1,312-ft) isobath appears to be the current economic limit for this type of structure.

Deepwater Operations Plans

A Deepwater Operations Plan (DWOP) is required for all deepwater development projects in water depths ≥1,000 ft (305 m) and for all projects proposing subsea production technology. A DWOP is designed to address industry and BOEMRE concerns by allowing an operator to know, well in advance of significant spending, that their proposed methods of dealing with situations not specifically addressed in the regulations are acceptable to BOEMRE. The DWOP provides BOEMRE with information specific to deepwater/subsea equipment issues to demonstrate that a deepwater project is being developed in an acceptable manner with regard to engineering specifics, safety, and the environment. The BOEMRE reviews deepwater development activities from a total system perspective, emphasizing the operational safety, environmental protection, and conservation of natural resources. A DWOP is required initially and is usually followed by a DOCD.

Development Operations and Coordination Document

The chief planning document that lays out an operator's specific intentions for development is the DOCD. The range of postlease development plans is discussed in **Chapter 1.5**. **Table 3-2** shows the estimated range of development wells and production structures by water depth subarea for the CPA proposed action. The BOEMRE estimates that 87-89 percent of development wells would become producing wells.

CPA Proposed Action Scenario: The BOEMRE estimates that 338-576 development wells will be drilled as a result of the CPA proposed action. **Table 3-2** shows the estimated range of development wells by water-depth range. Approximately 20-25 percent of the projected wells are expected to be on the continental shelf (0-200 m [656 ft] water depth) and 75-80 percent are expected in intermediate water-depth ranges and deeper (>200 m; 656 ft). For oil development wells (149-263), the water-depth range of 200-400 m (656-1,312 ft) has the largest portion of projected wells, about 25-26 percent. For gas development wells (144-237), the continental shelf (0-60 m [0-200 ft] water depth) has the largest portion of projected wells, about 23-28 percent.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. The BOEMRE estimates that 23,181-26,243 development wells will be drilled in the CPA as a result of the OCS Program. Tables 4-4, 4-5, and 4-6 in the Multisale EIS show the estimated range of development wells by water-depth range.

3.1.1.2.2. Infrastructure Presence

Chapter 4.1.1.3.3 of the Multisale EIS and Chapter 3.1.1.2.2 of the 2009-2012 Supplemental EIS describe the impacting factors arising from the presence of OCS facilities in the GOM as a result of a proposed action. These impacting factors include (1) anchoring, (2) offshore production systems, (3) space-use requirements, (4) aesthetic quality, and (5) trash and debris.

3.1.1.2.2.1. Anchoring

Chapter 4.1.1.3.1.1 of the Multisale EIS discusses the impacting factors arising from anchoring in the GOM as a result of the proposed action. Most exploration drilling, platform, and pipeline emplacement operations on the OCS require anchors to hold the rig, topside structures, or support vessels in place. Anchors disturb the seafloor and sediments in the area where dropped or emplaced. Anchoring can cause physical compaction beneath the anchor and chains or lines, as well as resuspend sediment. A disturbed area on the sea bottom forms by the swing arc formed by anchor lines scraping across bottom within the range allowed by the anchoring system configuration. Dynamically positioned rigs, production structures, and vessels are held in position by four or more propeller jets and do not cause anchoring impacts. Conventional pipelaying barges use an array of eight 9,000-kg (19,842-lb) anchors to position the barge and to move it forward along the pipeline route. These anchors are continually moved as the pipelaying operation proceeds. The area actually affected by these anchors depends on water depth, wind, currents, chain length, and the size of the anchor and chain. Mooring buoys may be placed near drilling rigs or platforms so that service vessels need not anchor, or cannot anchor (in deeper water). These temporarily installed anchors will most likely be smaller and lighter than those used for vessel anchoring and, thus, will have less impact on the sea bottom. Moreover, installing one buoy will preclude the need for numerous individual vessel-anchoring occasions. Service vessel anchoring is assumed not to occur in water depths >150 m (492 ft) and only occasionally in shallower waters (vessels would always tie up to a platform or buoy in water depths >150 m [492 ft]). Barges are assumed to always tie up to a production system rather than anchor. Barges and other vessels are also used for both installing and removing structures. Barge vessels use anchors placed away from their location of work.

3.1.1.2.2.2. Offshore Production Systems

Chapters 3.3.5.7.1 and 4.1.1.3.3 of the Multisale EIS and Chapter 3.1.1.2.2.1 of the 2009-2012 Supplemental EIS discuss the impacting factors arising from offshore production systems in the GOM as a result of a proposed action. **Table 3-2** shows the estimated number of production structures by water-depth range for the CPA proposed action.

Spar

A spar structure is a deep-draft, floating caisson that may consist of a large-diameter (27.4-36.6 m; 90-120 ft) cylinder or a cylinder with a lower tubular steel trellis-type component (truss spar, a second generation design) that supports a conventional production deck. A third generation of spar design is the cell spar. The cell spar’s hull is composed of several identically sized cylinders surrounding a center cylinder. The cylinder or hull may be moored via a chain catenary or semi-taut line system connected to 6-20 anchors on the seafloor. Spars are now used in water depths up to 900 m (2,952 ft) and may be used in water depths 3,000 m (9,842 ft) or deeper (NaturalGas.org, 2010a; USDOI, MMS, 2006b; Oynes, 2006).

Semisubmersibles

Semisubmersible production structures (semisubmersibles) resemble their drilling rig counterparts and are the most common type of offshore drilling rig (NaturalGas.org, 2010a). Semisubmersibles are partially submerged with pontoons that provide buoyancy. Their hull contains pontoons below the waterline and vertical columns that connect to the hull box/deck. The structures keep on station with conventional, catenary or semi-taut, line mooring systems connected to anchors in the seabed. Semisubmersibles can be operated in a wide range of water depths. Floating production systems are

suited for deepwater production in depths up to 8,000 ft (2,438 m) (NaturalGas.org, 2010a; USDOI, MMS, 2006b; Oynes, 2006).

Subsea Production Systems

For some development programs, especially those in deep- and ultra-deepwater, an operator may choose to use a subsea production system instead of a floating production structure. Although the use of subsea systems has recently increased as development has moved into deeper water, subsea systems are not new to the GOM and they are not used exclusively for deepwater development. Unlike wells from conventional fixed structures, subsea wells do not have surface facilities directly supporting them during their production phases. A subsea production system has various bottom-founded components. Among them are well templates, well heads, "jumper" connections between well heads, flow control manifolds, in-field pipelines and their termination sleds, and umbilicals and their termination assemblies. A subsea production system can range from a single-well template connected to a nearby manifold or pipeline, and then to a riser system at a distant production facility; or a series of wells that are tied into the system. Subsea systems rely on a "host" facility for support and well control. Centralized or "host" production facilities in deep water or on the shelf may support several satellite subsea developments. A drilling rig must be brought on location to provide surface support to reenter a well for workovers and other types of well maintenance activities. In addition, should the production/safety system fail and a blowout result, surface support must be brought on location to regain control of the well.

Floating Production, Storage, and Offloading Systems

This Agency prepared an EIS on the potential use of floating production, storage, and offloading (FPSO) systems on the Gulf of Mexico OCS (USDOI, MMS, 2001a). In accordance with the scenario provided by industry, the FPSO EIS addresses the proposed use of FPSO's in the deepwater areas of the CPA and WPA only. In January 2002, this Agency announced its decision to accept applications for FPSO's after a rigorous environmental and safety review. On June 12, 2007, this Agency received a DOCD from Petrobras Americas Inc. proposing to use an FPSO in Walker Ridge to develop two different CPA prospects: Cascade and Chinook. This is the first and only proposal, at this time, to use an FPSO in the GOM. The Cascade Prospect (Walker Ridge Block 206 Unit) is located approximately 250 mi (402 km) south of New Orleans, Louisiana, and about 150 mi (241 km) from the Louisiana coastline in approximately 8,200 ft (2,499 m) of water. The Chinook Prospect (Walker Ridge Block 425 Unit) is located about 16 mi (26 km) south of the Cascade Prospect. The FPSO was approved in 2011, but it has yet to be deployed.

3.1.1.2.2.3. Space-Use Requirements

Chapter 4.1.1.3.3.2 of the Multisale EIS and Chapter 3.1.1.2.2.2 of the 2009-2012 Supplemental EIS discuss impacting factors arising from space requirements in the GOM as a result of a CPA proposed action. Leasing on the OCS results in operations that temporarily occupy sea bottom and water surface area for dedicated uses. The OCS operations include the deployment of seismic vessels, bottom surveys, and the installation of surface or subsurface bottom-founded production structures with anchor cables and safety zones. While in use, these areas become unavailable to commercial fishermen or any other competing use.

CPA Proposed Action Scenario: A maximum of 264 ha (660 ac) (44 production structures of approximately 6 ha [15 ac]) of surface area will be lost to commercial fishing and other uses as a result of the CPA proposed action.

The net effect on total area available for commercial trawling and other uses will also be affected by structure removals. Structures removed in water depths <200 m (656 ft) in most cases would be taken to shore, resulting in trawl area being opened up. Approximately 10 percent of eligible structures removed are eventually used for rigs-to-reef. Those structures that may become artificial reef would open space where removed and take space where reefed. Even when platforms are transported to designated artificial reef planning areas, which already effectively prevent trawling, the net effect would again be additional trawling area. If platform removals are set against those installed, the effective net area taken for

temporary OCS use because of additional platforms is two platforms added to the CPA representing a net area taken of 11.5 ha (28 ac).

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. Total number of production structure installations in the CPA has been estimated through the years 2007-2046 in Table 4-6 of the Multisale EIS. The total number of production structure installations projected for the OCS Program over this period is shown in Table 4-4 of the Multisale EIS for both the WPA and CPA as 2,958-3,262 for all depth ranges. The total number of structure removals through the years 2007-2046 in the WPA and CPA are 5,997-6,097. With nearly double the amount of platform removals as installations, there would be no net OSC Program area taken over the 40-year analysis period by additional platforms. Because of structure removals, the net effect over this time is that more OCS space would become available for other uses. Cleared areas would once again be available for commercial fishing or any other competing use in depth ranges where the activities are practiced.

3.1.1.2.2.4. Aesthetic Quality

Chapter 4.1.1.3.3.3 of the Multisale EIS and Chapter 3.1.1.2.2.3 of the 2009-2012 Supplemental EIS describe the impacting factors arising from aesthetic interference in the GOM as a result of a proposed action. The presence of drilling and production platforms visible from land, increased vessel and air traffic, and noise are aesthetic inferences associated with the proposed action and routine events. The aesthetics for industrialized infrastructure is a subjective judgment, but it is usually regarded as a negative aesthetic if facilities of this type are visible. Visibility of industrial structures on an open horizon that may be frequented by people precisely for the open horizon is a net negative aesthetic and a conflict in space use. The potential visibility of fixed structures in local GOM waters could be of concern to business operators, local chambers of commerce, and organizations promoting tourism. Installed facilities and increased vessel and air traffic add a component of additional noise as well as their physical presence on the seascape.

The natural curvature of the Earth renders a 60-ft (18-m) tall ship invisible to a person at sea level when >12 mi (19 km) from shore. The formula for the distance to the horizon is given as your eye height above sea level, plus the height of the object under view, then square root of that sum, multiplied by 1.5 (WikiHow, 2010). Rasmussen (2008) includes a calculator. A structure 250 ft (76 m) above sea level, such as an oil platform, would not be visible to 6-ft-tall beach goers if it is >24 mi (38 km) from shore. The CPA is 3 nmi (3 mi; 6 km) from Louisiana, Mississippi, and Alabama. In the CPA, there are already nearly 1,000 platforms within 10 mi (16 km) of the coast (34% of the structures are in water depths <60 m [197 ft]), and for people living or visiting there, the presence of infrastructure on a "working coast" has been accepted.

CPA Proposed Action Scenario: Of the structures projected to be installed in water 0-60 m (0-197 ft) deep as a result of the CPA proposed action (**Table 3-2**), 20-25 would be located within 10 mi (16 km) of the coast and would be visible from the shore at sea level.

OCS Program Scenario: Of the structures projected to be installed in water 0-60 m (0-197 ft) deep as a result of the OCS Program in the CPA (Table 4-6 of the Multisale EIS), 612-645 would be located within 10 mi (16 km) of the coast and would be visible from the shore at sea level.

3.1.1.2.2.5. Workovers and Abandonments

Chapter 4.1.1.3.4 of the Multisale EIS and Chapter 3.1.1.2.2.4 of the 2009-2012 Supplemental EIS discuss the impacting factors arising from workovers and abandonments in the GOM as a result of a proposed action. Completed and producing wells may require periodic reentry that is designed to maintain or restore a desired product flow rate. These procedures are referred to as a well "workover." Workover operations are also carried out to evaluate or reevaluate a geologic formation or reservoir (including recompletion to another formation) or to permanently abandon a part or all of a well. Workovers on subsea completions require that a rig be moved on location to provide surface support. Workovers can take from 1 day to several months to complete, depending on the complexity of the operations, with a median of about 7 days. Based on historical data, BOEMRE projects a producing well may expect to have seven workovers or other well activities during its lifetime. There are two types of well abandonment operations—temporary and permanent. The operator must meet specific requirements

to decommission and abandon a well under guidelines provided in the new NTL 2010-G05 (**Chapter 3.1.1.7**). The projected number of workovers is a function of producing wells, including one permanent abandonment operation per well.

CPA Proposed Action Scenario: As a result of the proposed action, there are 2,000-2,849 workovers and other well activities estimated to be completed within the CPA.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. There are 190,778-218,555 workovers and other well activities in this class estimated to be completed within the OCS Program through the years 2007-2046.

3.1.1.3. Major Sources of Oil Inputs in the Gulf of Mexico

Petroleum hydrocarbons can enter the GOM from a wide variety of sources. The major sources of oil inputs in the GOM are natural seepage, produced waters, land-based discharges, and spills. These sources are discussed in detail in Chapter 4.1.3.4 of the Multisale EIS and in Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS. Numerical estimates of the contributions for these sources to the GOM coastal and offshore waters are shown in Tables 4-11 and 4-12 of the Multisale EIS, respectively. The information presented in the Multisale EIS is based on the National Research Council's *Oil in the Sea III: Inputs, Fates, and Effects* (NRC, 2003) and is summarized below.

The GOM comprises one of the world's most prolific offshore oil-producing provinces as well as having heavily traveled tanker routes. Nevertheless, inputs of petroleum from onshore sources far outweigh the contribution from offshore activities. Human use of petroleum hydrocarbons is generally concentrated in major municipal and industrial areas situated along coasts or large rivers that empty into coastal waters.

Natural Seepage

Natural seeps provide the largest petroleum input to the offshore GOM, about 95 percent of the total. Mitchell et al. (1999) estimated a range of 280,000-700,000 bbl per year (40,000-100,000 tonnes per year), with an average of 490,000 bbl (70,000 tonnes) for the northern GOM, excluding the Bay of Campeche. Using this estimate and assuming seep scales are proportional to surface area, the NRC (2003) estimated annual seepage for the entire GOM at ~980,000 bbl (140,000 tonnes) per year, or about 3 times the estimated amount of oil spilled by the 1989 *Exxon Valdez* event (~270,000 bbl) (Steyn, 2010) or a quarter of the amount released by the DWH event (4.9 million bbl of oil) (Lubchenco et al., 2010). As seepage is a natural occurrence, the rate of ~980,000 bbl (140,000 tonnes) per year is expected to remain unchanged throughout the 40-year cumulative analysis period.

Produced Water

During OCS operations, small amounts of oil are routinely discharged in produced water, which is treated and discharged overboard according to USEPA regulations. Based on the volume of produced water generated, an average of about 17,500 bbl of oil is discharged in the Gulf of Mexico OCS each year (Etkin, 2009).

Land-based Discharges

Land-based sources provide the largest petroleum input to the coastal waters of the GOM. Land-based sources include residual petroleum hydrocarbons in municipal and industrial wastewater treatment facility discharges as well as urban runoff. The Mississippi River carries the majority of petroleum hydrocarbons into GOM waters from land-based drainage that occurs far upriver. With increased urbanization, particularly in coastal areas, the amount of impervious paved surface increases, and oil contaminants deposited on these roads and parking lot surfaces are washed into adjacent streams and waterbodies.

Spills

Oil spills occur during the production, transportation, and consumption of oil. The composition of spilled hydrocarbons includes crude oil, refined fuels such as diesel during transport and storage and spills during consumption. Chapter 4.1.3.4.4 of the Multisale EIS and Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS, which discuss offshore and coastal spills and spills related to and not related to OCS activity, are summarized below. **Chapter 3.2.1** of this Supplemental EIS discusses potential spills associated with the proposed action, specifically. **Appendix D** discusses the *Deepwater Horizon* event.

At the national level, tankers and tank barges were responsible for 45 percent of the total spillage in the years 1969 through 2008 (U.S. Dept. of Homeland Security, CG, 2010a). The type of oil spilled nationally was as follows: 46 percent crude oil; 17 percent heavy fuel oil; 16 percent intermediate fuel oil; and 9 percent gasoline. Other petroleum and non-petroleum oils make up the remaining 11 percent (U.S. Dept. of Homeland Security, CG, 2010a). In the GOM, spills will vary according to activities conducted in the area. Spills from pipelines are the largest spill source of oil to the coastal waters of the western GOM. Spills from tankers are the largest spill source to coastal waters of the eastern GOM.

Spills could happen because of an accident associated with future OCS operations. Table 4-13 of the Multisale EIS provides the estimated number of all spill events (OCS and non-OCS) that BOEMRE projects will occur within coastal and offshore waters of the GOM area for a representative future year (around 15 years after the proposed action). Table 4-13 of the Multisale EIS distinguishes spill occurrence risk by likely operation or source and the estimated size of spills and shows the estimated number of annual OCS spills rather than for the 40-year program.

Spills as the Result of Hurricanes

Chapter 4.1.3.4.4.2 of the Multisale EIS and Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS discuss the cause and volume of spills that resulted from the 2002-2005 hurricanes. When spills related to hurricane damage are first reported, the amount of spilled crude oil and fuel products are estimated. Once safety issues are resolved and a more accurate accounting of lost material is made, the volumes often are corrected downwards. Therefore, this Agency updates and publishes these estimates in the years following the hurricanes. This Supplemental EIS revises the Multisale EIS and the 2009-2012 Supplemental EIS estimates. The most recent revision of petroleum spills from Federal OCS facilities caused by major hurricanes in 2002-2008 is available (USDOI, MMS, 2009a).

Table 3-4 indicates that spills caused by hurricane-damaged pipelines result in the vast majority of total oil spilled in the GOM. The BOEMRE reports production and spills in barrels; 1 bbl equals 42 U.S. gallons (gal). The USCG reports spills in gallons and classifies spills as minor, medium, or major. The table below presents the USCG volumes associated with spill size categories. The USCG's offshore spill size classifications are based solely on spill size, not impacts.

Spill Size	Volume of Oil Spilled
Minor	<238 bbl (<10,000 gal)
Medium	238-2,380 bbl (10,000-99,999 gal)
Major	≥2,381 bbl (≥100,000 gal)

- There were 231 spills totaling about 25,600 bbl identified as having occurred during or soon after the storms: 8 (totaling 1,631 bbl) from Hurricane Lili; 36 (totaling 4,645 bbl) from Hurricane Ivan; 73 (totaling 4,729 bbl) from Hurricane Katrina; 56 (totaling 8,734 bbl) from Hurricane Rita; and 58 (totaling 5,857 bbl) from Hurricanes Gustav and Ike.
- There were no major spills caused by any of the 2002-2008 hurricanes. The USCG defines a major offshore spill as a spill ≥100,000 gal (2,381 bbl) (based solely on size, not impacts).
- Of the 231 spills, 206 (89%) were minor, <238 bbl in size. These minor spills totaled <7,600 bbl, or about 30 percent of the spillage.

- There were a total of 25 medium spills, 238-2,380 bbl in size, totaling about 18,000 bbl (70% of the spillage): 3 from Hurricane Lili; 6 from Hurricane Ivan; 5 from Hurricane Katrina; 6 from Hurricane Rita; and 5 from Hurricanes Gustav and Ike. Only five of these medium spills were ≥1,000 bbl: 1 from Hurricane Ivan (1,720 bbl); 3 from Hurricane Rita (2,000 bbl, 1,572 bbl, and 1,494 bbl); and 1 from Hurricanes Gustav and Ike (1,316 bbl).
- Platforms and rigs were the source of 111 (48%) of the spills, totaling 16,838 bbl (66% of the spillage).
- Pipelines were the source of 120 (52%) of the spills identified, totaling 8,758 bbl (34% of the spillage).
- There were 80 spills of ≥50 bbl.

There were no accounts of environmental consequences resulting from spills from OCS facilities that occurred during these major hurricanes from 2002 through 2008. Impacts included the following (USDOI, MMS, 2009a):

- no spill contacts to the shoreline;
- no oiling of marine mammals, birds, or other wildlife;
- no large volumes of oil on the ocean surface to be collected or cleaned up; and
- no identified environmental impacts from any OCS spills from these hurricanes.

Offshore Spills

The OCS-related offshore spills and non-OCS-related offshore spills are addressed in Chapters 4.1.3.4.4.4 and 4.1.3.4.4.5 of the Multisale EIS, respectively, and in Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS. One OCS-related offshore spill of ≥1,000 bbl per year because of a pipeline release is anticipated. Besides spills occurring from facilities and during pipeline transport offshore spills could occur because of future FPSO operation or from shuttle tankers transporting OCS crude oil into ports. Table 4-13 of the Multisale EIS includes the likelihood of a spill from a shuttle-tanker accident carrying OCS-produced crude oil. The scenario with the highest risk of spill occurrence is the high-case resource estimate for the OCS Program in the CPA, which assumes some shuttle-tanker transport of OCS-produced oil. Under that scenario, there is a 63 percent chance that a spill ≥1,000 bbl and a 29 percent chance that a spill ≥10,000 bbl would occur from an OCS-related shuttle tanker during the 40-year cumulative analysis period. Offshore spill sizes were estimated based on historical records for a representative future year (Anderson and LaBelle, 2000).

Offshore OCS Program spills <1,000 bbl were estimated based on historical records collected from 1985 to 2001, and about 450-500 spills <1,000 bbl occurred from OCS offshore sources yearly. Less documentation is available for spills <1,000 bbl because they are more routine, they do not persist on the water as long, and they are likely to pose less of an environmental threat than larger spills. Additionally, many of the reported spills are of an unknown origin.

Non-OCS-related offshore spills ≥1,000 will occur from the extensive maritime barging and tankering operations that occur in offshore waters of the GOM. The analysis of spills from tankers and barges ≥1,000 bbl is based on data obtained from USCG and analyzed by BOEMRE. Less than one spill ≥1,000 bbl is projected to occur in the offshore GOM for a typical future year from the extensive tanker and barge operations (Table 4-13 of the Multisale EIS).

Coastal Spills

Table 4-13 of the Multisale EIS provides BOEMRE's projections of the number of spills that are projected to occur in the coastal waters of the GOM (State offshore and inland coastal waters) in a typical future year as a result of operations that support the OCS Program.

The OCS-related coastal spills are addressed in Chapter 4.1.3.4.4.6 of the Multisale EIS and in Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS. The OCS-related coastal spills primarily occur from pipeline ruptures. An OCS-related spill in coastal waters of ≥1,000 bbl and related to the proposed activity will occur less than once per year—about once every 6 years. An OCS-related spill ≥1,000 bbl would likely be from a pipeline accident for OCS coastal spills ≥1,000 bbl, where a spill size of 4,200 bbl is assumed. Smaller spills occur more regularly. Roughly 40-50 spills per year of <1,000 bbl related to the proposed activity on the OCS are estimated to occur in coastal waters. It is assumed that the spill risk would be widely distributed in the coastal zone, but it would primarily be within the Houston/Galveston area of Texas and the deltaic area of Louisiana due to the high proportion of oil being piped into these areas. Based on a BOEMRE analysis of USCG data on all U.S. coastal spills by volume, 42 percent of the spills will occur in State offshore waters, 1.5 percent will occur in Federal offshore waters, and 57 percent will occur in inland waters. It is assumed all coastal spills will contact land and proximate resources. For OCS-related coastal spills <1,000 bbl, a spill size of 5 bbl is assumed.

Non-OCS-related coastal spills are addressed in Chapter 4.1.3.4.4.7 of the Multisale EIS and in Chapter 3.1.1.3 of the 2009-2012 Supplemental EIS. Non-OCS-related coastal spills primarily occur from vessel accidents. Other sources include spills during the pipeline transport of petroleum products; crude oil; State oil and gas facilities; petrochemical refinery accidents; and storage tanks at terminals. A non-OCS-related coastal spill ≥1,000 bbl occurred roughly once every 2 years in the 1985-2001 USCG records. This is a very rough estimate because of the infrequent occurrence of a spill of this size in coastal waters. Non-OCS-related coastal spills <1,000 bbl occurred annually at a rate of 400-600 per year in the 1996-2001 USCG data. Many of the reported spills are from an unknown source. Based on a BOEMRE analysis of U.S. spill data maintained by USCG (U.S. Dept. of Homeland Security, CG, 2010a), the historical percentages of coastal spill occurrences in different waterbody types were calculated to be as follows: 47 percent have occurred in rivers and canals; 19 percent in bays and sounds; and 34 percent in harbors.

3.1.1.4. Offshore Transport

Chapter 4.1.1.8 of the Multisale EIS and Chapter 3.1.1.4 of the 2009-2012 Supplemental EIS describe the impact-producing factors arising from the transportation of products, supplies, and personnel in the GOM for a proposed action. The discussion in this Supplemental EIS tiers from the discussions in the Multisale EIS and the 2009-2012 Supplemental EIS.

3.1.1.4.1. Pipelines

Chapter 4.1.1.8.1 of the Multisale EIS and Chapter 3.1.1.4.1 of the 2009-2012 Supplemental EIS describe the existing pipeline network in the GOM, installation trends, installation methods, pipeline burial, and issues related to deep water. A mature pipeline network exists in the GOM to transport oil and gas production from the OCS to shore. There are currently 106 OCS-related pipeline landfalls (pipelines that have at one time or another carried hydrocarbon product from the OCS) in the Louisiana Coastal Area (LCA) (USDOI, MMS, 2007b, Table 3-38). Included in this figure is a subset of 47 pipeline systems under DOT jurisdiction originating in Federal waters and terminating onshore or in Louisiana State waters (Gobert, 2010) (**Figure 3-2**). The BOEMRE and DOT share responsibility for pipeline regulation on the OCS in the transition between Federal and State waters. The BOEMRE has jurisdiction over producer-operated pipelines that extend upstream from the wellbore to the point downstream (the last valve on production infrastructure) on the OCS at which responsibility transfers from a producing operator to a transporting operator. The DOT's jurisdiction lies with transporter-operated pipelines that tend to be larger diameter trunk lines that service multiple facilities or pipeline tie-ins from offshore.

The OCS-related pipelines nearshore and onshore may merge with pipelines carrying materials produced in State lands for transport to processing facilities or to connections with pipelines located farther inland (**Figure 3-2**). At present, all gas production and >99 percent of oil production from the offshore GOM is transported to shore by pipeline.

The BOEMRE's minimum cathodic protection design criteria for pipeline external corrosion protection is 20 years. For the most part, pipelines have a designed life span greater than 20 years and, if needed, can be retrofitted to increase the life span. As for internal corrosion mitigation, operators are

required to monitor products transported through the pipelines for corrosiveness. Based on the type of production, a company then enhances the pipeline internal corrosion protection by injecting appropriate corrosion inhibitors and monitoring effectiveness to prevent pipeline failures, thus extending the life of a pipeline. It should be noted that different products have different corrosive characteristics. Should a pipeline need to be replaced because of integrity issues, a replacement pipeline is installed or alternate routes are used to transport the products, or a combination of the two. Besides replacement because of integrity issues, a pipeline may also be required to be replaced as a result of storm or other damages. The BOEMRE estimates that the overall pipeline replacement over the past few years is about 1 percent of the total installed. Natural gas transportation by means other than pipelines, for example as LNG, is possible, but is not part of the proposed action or the OCS Program scenario.

Newer installation methods have allowed the pipeline infrastructure to extend farther into deep water. At present, the deepest pipeline in the Gulf is in water 2,700 m (8,858 ft) deep. More than 500 pipelines reach water depths of 400 m (1,312 ft) or more, and over 400 of those pipelines reach water depths of 800 m (2,625 ft) or more. These technical challenges are described in more detail in *Deepwater Gulf of Mexico 2006: America's Expanding Frontier* (USDOI, MMS, 2006b).

Pipeline Landfalls

Up to one (i.e., 0-1) new pipeline landfall is projected per OCS lease sale (USDOI, MMS, 2007d, p. 1). The BOEMRE anticipates that pipelines from most of the new offshore production facilities will tie in to the existing pipeline infrastructure offshore or in State waters, which will result in few new pipeline landfalls. Production from the CPA proposed action will contribute to the capacity of existing and future pipelines and pipeline landfalls. According to BOEMRE regulations (30 CFR 250.1003(a)(1)), pipelines with diameters ≥8⅝ inches (in) (22 centimeters [cm]) that are installed in water depths <60 m (200 ft) are to be buried to a depth of at least 3 ft (1 m) below mudline. The regulations also provide for the burial of any pipeline, regardless of size, if BOEMRE determines that the pipeline may constitute a hazard to other uses of the OCS in the GOM. The BOEMRE has determined that all pipelines installed in water depths <60 m (200 ft) must be buried. The purposes of these requirements are to (1) reduce the movement of pipelines during high sea states by storm currents and waves, (2) protect the pipeline from the external damage that could result from anchors and fishing gear, (3) reduce the risk of fishing gear becoming snagged, and (4) minimize interference with the operations of other users of the OCS. Where pipeline burial is necessary, a jetting sled would be used. Jetting disperses sediments over the otherwise undisturbed water bottom that flanks the jetted trench. The area covered by settled sediment and the thickness of the settled sediment depends upon variations in sea bottom grain size, bottom topography, sediment density, and currents. Sediment displacement due to pipeline burial is further explained in Chapter 4.1.1.3.2.2 of the Multisale EIS.

CPA Proposed Action Scenario: The BOEMRE projects 130-1,700 km (81-1,056 mi) of new pipelines as a result of the CPA proposed action (**Table 3-2**). For the CPA proposed action, about half of the new pipeline length would be in water depths <60 m (197 ft), requiring burial. For the CPA proposed action, 0-1 new pipeline landfalls are projected. The length of new pipelines was estimated using the amount of production, the number of structures projected as a result of the proposed action, and the location of the existing pipelines. The range in length of pipelines projected is because of the uncertainty of the location of new structures, which existing or proposed pipelines would be used, and where they tie in to existing lines. Many factors would affect the actual transport system, including company affiliations, amount of production, product type, and system capacity.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. Table 4-4 of the Multisale EIS projected that 9,470-66,550 km (5,884-41,352 mi) of new pipelines in support of the OCS Program during the years 2007-2046 would be built.

3.1.1.4.2. Barges

Chapters 3.3.5.8.9 and 4.1.1.8.2 of the Multisale EIS and Chapter 3.1.1.4.2 of the 2009-2012 Supplemental EIS describe the use of barges and oil barging. Barges may be used offshore to transport oil and gas, supplies such as chemicals or drilling mud, or wastes between shore bases and offshore

platforms in shallow waters (<60 m; <200 ft) of the GOM. A small amount (<1%) of oil production is barged in shallow water (<60 m; <200 ft).

CPA Proposed Action Scenario: The BOEMRE projects that barging will continue to account for ≤1 percent of the oil transported for the CPA proposed action.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS; that the current rate of barging would continue during the years 2007-2046 at about that same level as today or slightly less as production on the GOM tapers off in the second half of the 40-year production period.

3.1.1.4.3. Oil Tankers

Chapter 4.1.1.8.3 of the Multisale EIS and Chapter 3.1.1.4.3 of the 2009-2012 Supplemental EIS discuss the use of FPSO's and shuttle tankers for the transportation of OCS oil.

Shuttle tanker transport of Gulf of Mexico OCS-produced oil in a purpose-built FPSO system has not yet occurred; however, Petrobras had planned the Cascade-Chinook fields' first production from an FPSO and shuttle tanker system in mid-2010; however, delays following the DWH event has made scheduling difficult to predict. An FPSO was approved in 2011 but has yet to be deployed. Tankering is projected for some future OCS operations located in deep water beyond the existing pipeline network. The FPSO's store crude oil in tanks in the hull of the vessel and periodically offload the crude to shuttle tankers or oceangoing barges for transport to shore. The FPSO's may be used to develop marginal oil fields or used in areas remote from the existing OCS pipeline infrastructure, especially development in the Lower Eocene Wilcox trend (Walker Ridge leasing area) that is far from most existing pipeline networks. As a result of the CPA proposed action, the use of FPSO's and shuttle tankering are only projected in water depths >800 m (2,625 ft). Shuttle tankers would be used to transport crude oil from FPSO production systems to Gulf Coast refinery ports or to offshore deepwater ports such as the Louisiana Offshore Oil Port.

Safety features, such as marine break-away offloading hoses and emergency shut-off valves, would minimize the potential for, and size of, an oil spill. In addition, weather and sea-state limitations would be established to further ensure that hook-up and disconnect operations will not lead to accidental oil release. A vapor recovery system between the FPSO and shuttle tanker will be employed to minimize the release of fugitive emissions from cargo tanks during offloading operations. The FPSO systems are suitable for the light and intermediate oils of the GOM, as well as heavier oil, such as the heavy oil Brazil plans to produce offshore in deep water. The number of shuttle-tanker trips to port in a given year is primarily a function of the FPSO production rate and the capacity of supporting shuttle tankers.

CPA Proposed Action Scenario: There is one FPSO system ready to operate in the deepwater Gulf. The BOEMRE projects 0-1 FPSO systems could result from the CPA proposed action. For an FPSO operating at a peak production of 150,000 bbl/day, offloading would occur once every 3.3 days by a shuttle tanker with a 500,000-bbl cargo capacity transporting an upper-bound estimate of 54.75 MMbbl with 110 offloading events and shuttle tanker transits to offshore ports annually per FPSO system.

OCS Program Scenario: The OCS Program scenario did not offer a projection for shuttle tanker transport in the Multisale EIS because no FPSO system was then proposed in the GOM. As industry continues to explore the Eocene Wilcox trend, industry's interest level in the potential for the trend remains high, but flow assurance in these reservoirs remains a concern.

3.1.1.4.4. Service Vessels

Chapter 4.1.1.8.4 of the Multisale EIS and Chapter 3.1.1.4.4 of the 2009-2012 Supplemental EIS discuss the use of service vessels for transportation. Service vessels are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. In addition to offshore personnel, service vessels carry cargo (i.e., freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, and food) offshore. A trip is considered the transportation from a service base to an offshore site and back, in other words a round trip. Based on BOEMRE calculations, each vessel makes an average of eight round trips per week for 42 days in support of drilling an exploration well and six round trips per week for 45 days in support of drilling a development well. A platform in shallow water (<400 m; 1,312 ft) is estimated to require one vessel trip every 10 days over its 25-year production life. A platform in deep water (>400 m; 1,312 ft) is estimated

to require one vessel trip every 1.75 days over its 25-year production life. All trips are assumed to originate from the designated service base.

CPA Proposed Action Scenario: The CPA proposed action is estimated to generate 137,000-220,000 service-vessel trips over the 40-year period (**Table 3-2**) or 3,250-5,500 trips annually. Table 3-36 of the Multisale EIS indicates over 1.52 million service-vessel trips occurred on Federal navigation channels, ports, and OCS-related waterways in 2004. The number of service-vessel trips projected annually for the CPA proposed action would represent <1 percent of the total annual traffic on these OCS-related waterways.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. The projected number of service-vessel trips for the OCS Program is 6.71-8.6 million trips during the years 2007-2046 (Table 4-4 of the Multisale EIS).

3.1.1.4.5. Helicopters

Chapters 3.3.5.7.2.4 and 4.1.1.8.5 of the Multisale EIS and Chapter 3.1.1.4.5 of the 2009-2012 Supplemental EIS discuss the use of helicopters for the transportation of OCS crews and materials in support of OCS activities. The proposed action and OCS Program scenarios below use the current level of activity as a basis for projecting future helicopter operations. Helicopters are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. Helicopters are routinely used for normal crew changes and at other times to transport management and special service personnel to offshore exploration and production sites. In addition, equipment and supplies are sometimes transported by helicopter. The Federal Aviation Administration (FAA) regulates helicopter flight patterns. Because of noise concerns, FAA Circular 91-36C encourages pilots to maintain higher than minimum altitudes near noise sensitive areas. Corporate policy (for all helicopter companies) states that helicopters should maintain a minimum altitude of 700 ft (213 m) while in transit offshore and 500 ft (152 m) while working between platforms and drilling rigs. When flying over land, the specified minimum altitude is 1,000 ft (305 m) over unpopulated areas and coastlines, and 2,000 ft (610 m) over populated areas and sensitive areas including national parks, recreational seashores, and wildlife refuges. In addition, guidelines and regulations issued by NMFS under the authority of the MMPA include provisions specifying helicopter pilots to maintain an altitude of 1,000 ft (305 m) within 100 yd (91 m) of marine mammals. According to the Helicopter Safety Advisory Conference (2009), from 1996 to 2009, helicopter operations (take offs and landings) in support of Gulfwide OCS operations have averaged, annually, about 1.4 million operations, over 3.0 million passengers, and 430,000 flight hours. There has been a decline in helicopter operations from 1,668,401 in 1996 to 1,397,508 in 2009 (Helicopter Safety Advisory Conference, 2009).

CPA Proposed Action Scenario: There are 1,000,000-2,200,000 helicopter trips projected over the 40-year period for the CPA proposed action (**Table 3-2**), or 25,100-55,025 trips annually.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. Table 4-4 of the Multisale EIS projects 38-60 million helicopter trips for the OCS Program for the years 2007-2046.

3.1.1.5. Operational Wastes and Discharges

Chapter 4.1.1.4 of the Multisale EIS describes the impacting factors arising from operational wastes and discharges in the GOM resulting from a proposed action. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS. Because these wastes and discharges are USEPA-permitted routine wastes types and volumes, they are also discussed under water quality as an impact of routine events (**Chapter 4.1.2.2.2**). Aside from the reissuance of expiring general NPDES permits by USEPA, there has been very little change in the topic of wastes and discharges. Volumes or wastes and discharges are dependant upon the level of activity, and hence, operations in the GOM.

The USEPA, through general permits issued by the Region that has jurisdictional oversight, regulates all waste streams generated from offshore oil and gas activities. Each USEPA Region has promulgated general permits for discharges that incorporate the 1993 and 2001 effluent limitations guidelines as a minimum. **Figure 3-3** shows the areas of the GOM where BOEMRE and USEPA have jurisdiction for air emissions. Within USEPA Region 6, BOEMRE has air emission jurisdiction on the OCS west of 87.5^{o} W. longitude. The current Region 6 general permit (GMG290000) was issued on June 7, 2007, and

expires September 30, 2012 (USEPA, 2007a). In accordance with BOEMRE's air quality regulations, BOEMRE applies defined criteria to determine which OCS plans require an air quality review and performs an impact analysis on the selected plans to determine whether the emission source would potentially cause a significant onshore impact.

Drilling Muds and Cuttings

Drilling mud and cuttings are described in Chapter 4.1.1.4.1 of the Multisale EIS. Drilling fluid is used during the drilling of exploration and development wells. These fluids are very dense and are circulated down the wellbore to pick up and remove drill bit cuttings, after which the mixture of entrained cuttings and fluid is referred to as drilling mud.

The composition of drilling fluids is complex. Drilling fluids used on the OCS are divided into two categories: water based and nonaqueous based, in which the continuous phase is not soluble in water. Clays, barite, and other chemicals are added to the base fluid, which can be freshwater or saltwater in water-based fluids (WBF's), mineral or diesel oil-based fluids (OBF's), or synthetic-based fluids (SBF's). Additional chemicals may be added to improve the performance of the drilling fluid (Boehm et al., 2001).

Drilling mud is reconditioned and recirculated at the surface. The OBF's are rarely used in GOM operations, while SBF's may be preferred for certain deepwater prospects. If used, OBF's and SBF's must be recovered and taken to shore for recycling. Only water-based drill mud meeting USEPA's NPDES permit requirements may be discharged to the sea. Barite is a major mineral component of all drilling fluid types. Barite is used to "heavy up" drilling mud because of the high specific gravity of barite. Adding barite makes drilling mud denser and heavier. Many other products are added to improve and condition the drilling fluid. Drilling mud that is discharged must meet USEPA's NPDES permit requirements that include limits on trace metal concentrations, free oil, and toxicity. The USEPA regulates the NPDES permit program in the WPA.

Cuttings are the chipped and fragmented rock that is broken and removed by the rotating drilling bit and brought to the surface entrained in drilling fluid. Cuttings may be discharged if they meet the USEPA's NPDES permit requirements that include limits on adhered synthetic mud, if used, as well as limits on trace metals, toxicity, polycyclic aromatic hydrocarbons, and free oil.

Produced Waters

Produced waters are described in Chapter 4.1.1.4.2 of the Multisale EIS. Produced water is water that originates from or passes through the hydrocarbon-bearing geological strata and is brought to the surface with oil and gas during production. This waste stream can include formation water; injection water; well treatment, completion, and workover compounds added downhole; and compounds used during the oil and water separation process. Formation water, also called connate water or fossil water, originates in the permeable sedimentary rock strata and is brought up to the surface commingled with the oil and gas. Injection water is water that was injected to enhance oil production and in secondary oil recovery.

Produced water is the largest volume byproduct associated with oil and gas exploration and production (Clark and Veil, 2009). The vast majority of OCS produced water is treated to remove oil and grease to a concentration below 29 milligrams/liter (mg/L) monthly average and discharged. In the OCS waters off the State of Texas, less produced water is generated because these wells tend to be gas. The oil wells in the OCS waters off the State of Louisiana generated greater volumes of produced water. Clark and Veil (2009) have determined the ratio of produced water to oil and gas on the OCS to be 1.04 bbl produced water to 1 bbl oil, and 86.0 bbl produced water to 1 million cubic feet (MMcf) of gas, respectively. The USEPA general permits allow the discharge of produced water on the OCS provided they meet discharge criteria.

Well-Treatment, Workover, and Completion Fluids

Well-treatment, workover, and completion fluids are described in Chapter 4.1.1.4.3 of the Multisale EIS. Completion fluids are used to displace the drilling fluid and protect formation permeability. Workover fluids are used to maintain or improve existing well conditions and production rates on wells that have been in production. These fluids include mixtures of seawater with various salts, such as

calcium chloride and calcium bromide, and may include defoamers and corrosion inhibitors or acids to increase formation permeability.

Production treatment fluids are chemicals applied during the oil and gas extraction process. Production chemicals are used to dehydrate produced oil or treat the associated produced water for reuse or disposal. Both USEPA Regions 4 and 6 allow the discharge of well-treatment, completion, and workover fluids that meet the specified guidelines. Production chemicals consist of corrosion and scale inhibitors, bactericides, paraffin solvents, demulsifiers, foamers, defoamers, and water treatment chemicals.

The USEPA Regions 4 and 6 allow the discharge of well-treatment, completion, and workover fluids that meet the specified guidelines; although if recoverable in concentration, they may be collected and recycled at an onshore facility.

Production Solids and Equipment

Production solids are described in Chapter 4.1.1.4.5 of the Multisale EIS. Produced sands are entrained particles that surface after hydraulic fracturing, and sand disassociated from the formation, along with other particles including pipe scale that are produced. Production solids may not be discharged overboard and are collected on the production platform, stored, and ultimately transported to shore for disposal. The solids are disposed of as nonhazardous oil-field waste according to individual State regulations.

Deck Drainage

Deck drainage is described in Chapter 4.1.1.4.5 of the Multisale EIS. Deck drainage includes all wastewater resulting from platform washings, deck washings, rainwater, and runoff from curbs, gutters, and drains, including drip pans and work areas, that is collected in separators that can remove oils and greases before overboard discharge. The USEPA's general guidelines for deck drainage require that no free oil be discharged, as determined by visual sheen.

Domestic and Sanitary Wastes

Domestic and sanitary wastes are described in Chapter 4.1.1.4.6 of the Multisale EIS. As with the waste streams discussed above, domestic and sanitary wastes may be discharged when they are treated to meet USEPA-regulated parameters. Most service and crew vessels use a marine sanitation device Type III that stores sanitary wastes in tanks aboard ship until transferred to treatment facilities onshore at the service base.

Vessel Operational Wastes

Vessel operational wastes are described in Chapter 4.1.1.4.8 of the Multisale EIS. Vessel regulations come under the jurisdiction of USCG. The USCG and USEPA have cooperatively set regulatory limits for wastes, such as sanitary waste, which both agencies regulate, depending upon vessel type and location. Regulated wastes include bilge and ballast waters, trash and debris, and sanitary and domestic wastes.

Trash and Debris

Trash and debris are described in Chapter 4.1.1.5 of the Multisale EIS. The OCS oil and gas operations generate trash and debris materials made of paper, plastic, wood, glass, and metal. Most of this trash is associated with galley and offshore food service operations and with operational supplies such as shipping pallets, containers used for drilling muds and chemical additives (sacks, drums, and buckets), and protective coverings used on mud sacks and drilling pipes (shrink wrap and pipe-thread protectors). Trash is collected and stored on the lower deck near the loading dock in large receptacles resembling dumpsters. These large containers are generally covered with netting to avoid loss and are returned to shore by service vessels for disposal in landfills. Drilling operations require the most

supplies, equipment, and personnel; therefore, drilling operations generate more solid trash than production operations.

Noise

Noise is described in Chapter 4.1.1.7 of the Multisale EIS. Coastal noise associated with OCS oil and gas development results from helicopter and service-vessel traffic. Sound generated from these activities can be transmitted through both air and water, and may be continuous or transient. Service vessels transmit noise through both air and water. The primary sources of vessel noise are propeller cavitation, propeller singing, and propulsion; other sources include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al., 1995). Propeller cavitation is usually the dominant noise source. The intensity of noise from service vessels is roughly related to ship size and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. Noise increases with ship speed; ship speeds are often reduced in restricted coastal waters and navigation channels.

Air Emissions

Air emissions are described in Chapter 4.1.1.6 of the Multisale EIS. In 1990, pursuant to Section 328 of the Clean Air Act Amendments and following consultation with the Commandant of the U.S. Coast Guard and the Secretary of the Interior, USEPA assumed air quality responsibility for the OCS waters east of 87.5^{o} W. longitude and this Agency retained National Ambient Air Quality Standards (NAAQS) air quality jurisdiction for OCS operations west of 87.5^{o} W longitude in the GOM.

Air pollutants are emitted from the OCS emission sources that include any equipment that combusts a fuel, transports and/or transfers hydrocarbons, or results in accidental releases of petroleum hydrocarbons or chemicals, causing air emissions of pollutants. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. Air pollutants are generated during exploration and production activities when fuels are combusted to run drilling equipment, power generators, and run engines. During production, fugitive emissions, including volatile organic compounds, escape from valves and flanges. Criteria air pollutants are also generated along routes from shore bases to OCS leases by vessels transporting supplies and workers.

The air pollutants are also released during both venting and flaring. A combustion flare or cold vent is a specially designed boom or stack used to dispose of hydrocarbon vapors or natural gas. Unlike cold vents, the hydrocarbons are ignited during flaring. Flares can be used routinely to control emissions as part of unloading/testing operations that are necessary to remove potentially damaging completion fluids from the wellbore and to provide sufficient reservoir data for the operator to evaluate a reservoir and development options; they can also be used during emergency process upsets. The BOEMRE regulations provide for some limited volume, short duration flaring or venting of oil and natural gas upon approval by BOEMRE (2-14 days, typically). Through 30 CFR 250.1162, BOEMRE may allow operators to burn liquid hydrocarbons if they can demonstrate that transporting them to market or re-injecting them into the formation is not technically feasible or poses a significant risk of harm to the environment. During the DWH event, BP received permission from BOEMRE to burn oil and flare gas because the lessee initiated an action which, when completed, will eliminate the need for flaring. In this case the action was a relief well to kill the Macondo spill.

3.1.1.6. Safety Issues

This chapter describes safety issues arising in the GOM resulting from the proposed action. These issues include (1) hydrogen sulfide and sulfurous petroleum, (2) shallow hazards, and (3) new and unusual technologies.

3.1.1.6.1. Hydrogen Sulfide and Sulfurous Petroleum

Chapter 4.1.1.9 of the Multisale EIS and Chapter 3.1.1.5.1 of the 2009-2012 Supplemental EIS describe the impacting factors arising from hydrogen sulfide (H_2S) and sulfurous petroleum in the GOM resulting from a CPA proposed action. Sulfur may be present in oil as elemental sulfur, within gas as

H_2S, or within organic molecules, all three of which vary in concentration independently. Safety and infrastructure concerns include the following: irritation, injury, and lethality from leaks; exposure to sulfur oxides produced by flaring; equipment and pipeline corrosion; and outgassing and volatilization from spilled oil.

Sour oil and gas occur sporadically throughout the Gulf of Mexico OCS, primarily off the Louisiana, Mississippi, and Alabama coasts. Sour hydrocarbon tends to originate in carbonate source or reservoir rocks that may not have abundant clay minerals that serve as a binder for elemental sulfur. If not bound in clay minerals, it remains free and can become a part of any hydrocarbon produced or sourced from that rock.

Deep gas reservoirs on the GOM continental shelf are likely to have high corrosive content, including H_2S. There is some evidence that petroleum from deepwater areas may be sulfurous, but exploration wells have not identified deepwater areas that are extraordinarily high in H_2S concentration.

The BOEMRE reviews all exploration and development plans in the Gulf of Mexico OCS to account for the possible presence of H_2S in the area(s) identified for exploration and development activities. Activities determined to be associated with a presence of H_2S are subjected to further review and requirements. Federal regulations at 30 CFR 250.490 require all lessees, prior to beginning exploration or development operations, to request a classification of the potential for encountering H_2S. The classification is based on previous drilling and production experience in the areas surrounding the proposed operations, as well as other factors.

All operators on the OCS involved in production of sour gas or oil (i.e., >20 ppm) are also required to file an H_2S Contingency Plan. This plan lays out procedures to ensure the safety of the workers on the production facility. In addition, all operators are required under 30 CFR 250.198 to adhere to the National Association of Corrosion Engineers' (NACE) *Standard Material Requirements—Methods for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments* (NACE MR0175-2003) (NACE, 2003) as best available and safest technology. These engineering standards preserve the integrity of infrastructure through specifying equipment to be constructed of materials with metallurgical properties that resist or prevent sulfide stress cracking and stress corrosion cracking in the presence of sour gas. This Agency issued a final rule (30 CFR 250.490; *Federal Register*, 1997a) governing requirements for preventing hydrogen sulfide releases, detecting and monitoring hydrogen sulfide and sulfur dioxide, protecting personnel, providing warning systems and signage, and establishing requirements for hydrogen sulfide flaring and venting.

3.1.1.6.2. Shallow Hazards

The Multisale EIS did not contain a discrete discussion about shallow hazards. Pre-drill seismic assessment of drilling hazards is an essential part of the well planning process. The type of high-resolution seismic surveys that are deployed to collect the data used for shallow hazards analyses are described in **Chapter 3.1.1.1.1**.

Shallow hazard assessments are required by BOEMRE regulations (30 CFR 250.214 and 30 CFR 250.244); NTL 2008-G05, "Shallow Hazards Program," explains the requirements for these surveys and their reports. Included in shallow hazard assessment is a structural and stratigraphic interpretation of seismic data to qualitatively delineate abnormal pressure zones, shallow free gas, seafloor instability, shallow water flow, and gas hydrates.

The objective of the shallow hazard assessment is to identify, map, and delineate seafloor, shallow subsurface geologic features, and man-caused obstructions that may impact proposed oil and gas operations, which include the following:

- seafloor geologic hazards such as fault scarps, gas vents, unstable slopes, and reefs;
- shallow subsurface geologic hazards such as faults, gas hydrates and gas-charged sediments, buried channels, and abnormal pressure zones; and
- synthetic hazards such as pipelines, wellheads, shipwrecks, military ordnance (offshore disposal sites), and debris from oil and gas operations.

The shallow hazards survey is also used to identify and map geologic features in the vicinity of proposed wells, platforms, anchors and anchor chains, mounds or knolls, acoustic void zones, gas- or oil-charged sediments, or seeps associated with surface faulting that may be indicative of ocean-bottom chemosynthetic communities.

Since 1987, operators have reported shallow waterflow events to this Agency. These events are a phenomenon encountered in water depths exceeding 600 ft (183 m). Reported waterflows are between a few hundred feet to more than 4,000 ft (1,219 m) below the seafloor. Water flowing up and around the well casing and annulus may deposit sand or silt on the seafloor within a few hundred feet of the wellhead. Although in most cases there is no gas content in the waterflow, in these water depths a stream of gas bubbles may form frozen gas hydrates at the sea bottom and on flat surfaces of seafloor drilling equipment. Shallow waterflows can result from buried channels filled with more permeable sediment. Abnormally pressured shallow sands may result from either rapid slumping or rotating faults or from reworked cut-and-fill channels sealed by impermeable mud or clay. In rare cases, hydrates below the mudline could be a source of shallow waterflow by melting down hydrates during oil production. Shallow waterflow events can cause additional expenditure of time and money for the driller to maintain well control and can lead to drilling difficulty up to and including a decision to permanently plug and abandon the well. Unanticipated shallow hazards can lead to downhole pressure kicks that range from minor and controllable to significant and uncontrollable; up to and including a serious blowout condition.

3.1.1.6.3. New and Unusual Technology

Chapter 4.1.1.10 of the Multisale EIS discusses the impacting factors arising from the environmental and engineering safety review processes for new and unusual technology in the GOM resulting from a proposed action. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS.

Operators must identify new and unusual technology in exploration and development plans. The new and unusual technologies are reviewed by BOEMRE for alternative compliance with permits or departures that may trigger additional environmental review.

In addition to new and unusual technology for drilling, as a result of the DWH event, many technologies or applications were developed in attempting to stop the spill and kill the well. The NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," applies to operators conducting operations using subsea BOP's or surface BOP's on floating facilities. The BOEMRE will now assess whether each lessee has submitted adequate information demonstrating that it has access to and can deploy surface and subsurface containment resources that would be adequate to promptly respond to a blowout or other loss of well control. Containment resources could consist of, but are not limited to, subsea containment and capture equipment including containment domes and capping stacks, subsea utility equipment including hydraulic power, hydrate control, and dispersion injection equipment.

3.1.1.7. Decommissioning and Removal Operations

Chapter 4.1.1.11 of the Multisale EIS and Chapter 3.1.1.6 of the 2009-2012 Supplemental EIS describe impacting factors arising from decommissioning and removal operations in the GOM. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and in the 2009-2012 Supplemental EIS.

The BOEMRE's regulations for wellheads/casing (30 CFR 250.1710) platforms and other facilities (30 CFR 250.1725) require operators to remove all seafloor obstructions from their leases within 1 year of lease termination or relinquishment. These regulations require lessees to sever bottom-founded structures and their related components at least 5 m (15 ft) below the mudline to ensure that nothing would be exposed that could interfere with future lessees and other activities in the area.

In 2008, this Agency conducted an Alternative Internal Control Review of idle structures and wells on active leases on the Gulf of Mexico OCS. This review evaluated the presence of idle infrastructure and a process of identifying, tracking, and decommissioning idle wells and structures. Findings indicated that there are a significant number of idle platforms that have not been removed and idle wells that have not been permanently plugged. Idle infrastructure poses a potential threat to the OCS environment and is a financial liability to operators and the Federal Government if it is subsequently destroyed or damaged in a future event, such as a hurricane. The cost and time to permanently plug wells and remove storm-

damaged infrastructure (including pipelines) is significantly higher than decommissioning assets that are not damaged when decommissioned. Increased costs to deal with idle but damaged infrastructure has potential ramifications on the operators' financial security requirements to operate on the OCS or even their financial viability.

On September 15, 2010, BOEMRE launched plans to clear the GOM of "idle iron;" requiring companies to dismantle deserted platforms and permanently plug thousands of abandoned oil and gas wells, including some that are decades old (Dloughy, 2010). The mandate will affect nearly 3,500 nonproducing wells and require the decommissioning of about 650 unused oil and gas production platforms. The new NTL 2010-G05, "Decommissioning Guidance for Wells and Platforms," became effective on October 15, 2010, and clarifies the operator's procedures for abandoning platforms and wells.

Until now, the decommissioning and removal of infrastructure and the plugging and abandoning of nonproducing wells was required within a year after an operator's offshore oil and gas lease expired. Historically, that policy gave companies plenty of time and freedom to use once-abandoned platforms and other infrastructure to support future wells and other projects. The NTL 2010-G05 explains the approach to ensure that idle infrastructure on active leases is decommissioned in a timely manner. It also provided definitions for the following: (1) capable of production in paying quantities; (2) downhole zonal isolation; (3) no longer useful for operations; and (4) toppled platform. The NTL also clarified, described, and interpreted many other issues regarding decommissioning that have arisen since publication of 30 CFR 250 Subpart Q in 2002. The NTL 2010-G05 now clarifies the regulations that require the operator to plug any well that has been idle for the past 5 years, along with any associated platforms and pipelines serving it, even if they are part of an active offshore lease.

A well that is no longer useful for operations is defined as one that

- has not been used in the past 5 years for operations associated with the exploration for or the development and production of oil, gas, sulphur, or other mineral resource or as infrastructure to support such operations; and
- has no plans for operations associated with the exploration for or the development and production of oil or gas, or as infrastructure to support such operations.

A platform or structure that is no longer useful for operations is defined as one that

- has been toppled or otherwise destroyed; or
- has not been used in the past 5 years for operations associated with the exploration for or the development and production of oil or gas, sulfur, or other mineral resource or as infrastructure to support such operations.

Programmatic Environmental Assessment

This Agency prepared *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (Programmatic EA) (USDOI, MMS, 2005) to evaluate the full range of potential environmental impacts of structure-removal activities in all water depths in the CPA and WPA and in the areas of the EPA then open for leasing. The activities analyzed in the Programmatic EA include vessel and equipment mobilization, structure preparation, nonexplosive- and explosive-severance activities, post-severance lifting and salvage, and site-clearance verification. The impact-producing factors of structure removals considered in the Programmatic EA include seafloor disturbances, air emissions, water discharges, pressure and acoustic energy from explosive detonations, and space-use conflicts with other OCS users. No potentially significant impacts were identified for air and water quality; marine mammals and sea turtles; fish, benthic communities, and archaeological resources; or other OCS pipeline, navigation, and military uses.

On the basis of the Programmatic EA, this Agency determined that an EIS was not required and prepared a Finding of No Significant Impact on February 15, 2005. On February 28, 2005, this Agency submitted the new structure-removal Programmatic EA and a petition for new Incidental-Take Regulations under the MMPA to NMFS. After review of the petition and Programmatic EA, NMFS published a Notice of Receipt of the Agency's Petition in the *Federal Register* on August 24, 2005. Only

one comment was received by NMFS during the public comment period. On April 7, 2006, NMFS published the Proposed MMPA Rule for the Incidental Take of marine mammals in the *Federal Register* and the subsequent public comment period ended May 22, 2006. In addition, NMFS conducted a Section 7 ESA Consultation on their MMPA rulemaking efforts. The consultation was completed and this Agency received a new Biological Opinion and Incidental Take Statement (ITS) on August 28, 2006, which superseded the previous "generic" and "de-minimus" Biological Opinions/ITS's. On June 19, 2008, NMFS finalized their MMPA rulemaking efforts and published the Final Rule for take-regulations for explosive severance, which are located in Subpart S of the MMPA regulations at 50 CFR 216.211-219.

Removal of Bottom Debris

Chapter 4.1.1.3.3.4 of the Multisale EIS and Chapter 3.1.1.6 of the 2009-2012 Supplemental EIS discuss bottom debris, which is defined as material resting on the seabed (such as cable, tools, pipe, drums, anchors, and structural parts of platforms, as well as objects made of plastic, aluminum, wood, etc.) that are accidentally lost (e.g., during hurricanes) or swept overboard from fixed or floating facilities. The maximum quantity of bottom debris per operation is estimated to be several tons. The BOEMRE requires site clearance over the assumed areal extent over which debris will fall. It is assumed that lost debris will be removed from the seafloor during the structure decommissioning, site clearance, and verification process.

Explosive and Nonexplosive Removals

A varied assortment of severing devices and methodologies has been designed to cut structural targets during the course of decommissioning activities. These devices are generally grouped and classified as either nonexplosive or explosive. Which severing tool the operators and contractors use takes into consideration the target size and type, water depth, economics, environmental concerns, tool availability, and weather conditions. The BOEMRE anticipates that multiple appurtenances will not be removed from the seafloor if placed in waters exceeding 800 m (2,625 ft). No explosive removals are projected in water depths >800 m (2,625 ft) because OCS regulations would offer the lessees in those water depths the option to avoid any severance/removal work by requesting alternate removal depths for well abandonments (30 CFR 250.1716(b)(3)) and facilities (30 CFR 250.1728(b)(3)). Above mudline cuts would be allowed with reporting requirements on the remnant's description and height off of the seafloor to BOEMRE. These data are necessary for subsequent reporting to the U.S. Navy. In most cases, industry has indicated that it would use the alternate removal depth options, coupled with quick-disconnect equipment (i.e., detachable risers, mooring disconnect systems, etc.) to fully abandon in-place wellheads, casings, and other minor subsea equipment in deep water without the need for any severing devices.

CPA Proposed Action Scenario: **Table 3-2** reports platform removals by water-depth range as a result of the CPA proposed action. Of the 30-42 total production structures estimated to be removed as a result of the CPA proposed action, 15-20 production structures (installed landward of the 800-m [2,625-ft] isobath) are likely to be removed using explosives.

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. Table 4-4 of the Multisale EIS reports that the number of production structures estimated to be removed during the years 2007-2046 is about twice the number of production structures estimated to be installed during the same time period.

3.1.2. Coastal Impact-Producing Factors and Scenario

Chapter 4.1.2 of the Multisale EIS and Chapter 3.1.2 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from OCS-related infrastructure and its use during a proposed action in the GOM. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and the 2009-2012 Supplemental EIS.

Coastal impacting factors include (1) service bases and navigation channels, (2) gas processing plants, (3) coastal pipelines, and (4) disposal facilities for offshore operations. The Multisale EIS also discussed topical headings of helicopter hubs, construction facilities, terminals, and coastal barging. These

elements of OCS-related infrastructure as coastal impacting factors have not appreciably changed since the 2009-2012 Supplemental EIS and those discussions are hereby incorporated by reference into this Supplemental EIS.

Chapter 4.1.2.1 of the Multisale EIS and Chapter 3.1.2 of the 2009-2012 Supplemental EIS describe the potential need for construction of new facilities and existing facility expansions that may result from a proposed lease sale and the OCS Program. Projected new coastal infrastructure as a result of the OCS Program is shown by State in Table 4-9 of the Multisale EIS. The following information summarizes the scenario analysis incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS and provides new information collected since these documents were prepared.

The BOEMRE has reexamined the scenario analysis presented in the Multisale EIS and in the 2009-2012 Supplemental EIS in light of the DWH event. To date, there has been an influx of much new information related to the oil spill. However, it is too early to determine conclusively whether or not the scenario analysis should be modified, and if it were, what these changes would encompass. The presence of coastal infrastructure is not subject to rapid fluctuations. Infrastructure projections reflect long-term industry trends, and changes to these trends cannot be determined from the few months of post-DWH data that are available. While changes (if any) to the current scenario analysis due to the DWH event and its aftermath are not expected, BOEMRE will continue to collect new data and to monitoring of changes in infrastructure demands in order to support scenario projections that reflect current and future industry conditions.

According to the scenario analysis in the Multisale EIS and in the 2009-2012 Supplemental EIS, the construction of 0-1 new gas processing facilities would be expected to occur near the end of the 40-year life of a single lease sale. Most of the projected new pipelines would be offshore and would tie into the existing offshore pipeline infrastructure, with 0-1 new pipeline landfalls expected to occur toward the end of the 40-year lifespan of a lease sale. The lingering effects of the drilling moratorium and changes in Federal requirements for drilling safety has depressed demand for gas processing facilities and pipeline landfalls. Given this uncertain environment post-DWH, the likelihood is diminished that any new gas processing facility or pipeline landfall would result from a single lease sale and, hence, the likelihood of new facilities or pipeline landfalls has moved closer to zero and farther from one (Dismukes, personal communication, 2010a). Maintenance dredging of existing navigation channels is still expected, but no new navigation channels are expected to be dredged as a result of the proposed action. The analyses of coastal infrastructure presented in the Multisale EIS concluded that no new solid-waste facilities would be built as a result of a single lease sale or as a result of the OCS Program. Recent research further supports these past conclusions that existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs. The volume of OCS waste generated is closely correlated with the level of offshore drilling and production activity. Demand for waste disposal facilities is influenced by the volume of waste generated (Dismukes et al., 2007). At this time, it is unclear how long this temporary interruption in activity will continue or how it might affect later years. Until OCS drilling activity recovers, the potential for a new waste facility as a result of the proposed action is highly unlikely; however, such a conclusion remains tentative at this early date post-DWH.

The source of the majority of the information on coastal infrastructure and activities presented in the Multisale EIS is this Agency's study, *OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (The Louis Berger Group, Inc., 2004). An update of this fact book, *OCS-Related Infrastructure Fact Book: Post-Hurricane Impact Assessment (Volume I) and Communities in the Gulf of Mexico (Volume II)*, is nearly complete (Dismukes, in preparation-a). Within the last 4 years, this Agency analyzed historical data and validated past scenario projections of new pipeline landfalls and new onshore waste disposal sites (USDOI, MMS, 2007d and 2007e).

The following coastal infrastructure types are highlighted for discussion because new general information is available, new facilities are projected to be constructed as a result of the proposed action, and/or new information relevant to discussions of the DWH event is available.

3.1.2.1. Service Bases

Chapter 4.1.2.1 of the Multisale EIS and Chapter 3.1.2.1 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from service bases in the GOM. A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel that are needed at offshore

work sites. Chapters 3.3.5.8.1 and 4.1.2.1.1 of the Multisale EIS present a detailed description of OCS-related service bases. While no proposed action is projected to significantly change existing OCS-related service bases or require any additional service bases, a proposed action would contribute to the use of existing service bases. **Figure 3-4** shows the 50 service bases the industry currently uses to service the OCS. These facilities were identified as the primary service bases from plans received by BOEMRE. The ports of Fourchon, Cameron, Venice, and Morgan City, Louisiana, are the primary service bases for GOM mobile rigs. Major platform service bases are Galveston, Freeport, and Port O'Connor, Texas; Cameron, Fourchon, Intracoastal City, Morgan City, and Venice, Louisiana; Pascagoula, Mississippi; and Theodore, Alabama.

Exploration and development plans received by BOEMRE identify primary and secondary service bases for three types of support: supply vessel; crewboat; and helicopter. Supply vessel bases are loading points and provide temporary storage for supply vessels that transport pipe and bulk supplies. Crewboats transport personnel and small supplies. Collectively, supply vessels and crewboats are known as offshore supply vessels (OSV's). Approximately 1,200 OSV's are operating in the GOM. Important drivers for the OSV market include the level of offshore exploration and drilling activities, current oil and gas prices, expectations for future oil and gas prices, and customer assessments of offshore prospects (Dismukes, in preparation-b). Helicopters transport personnel and small supplies, and they may also patrol pipelines to spot signs of damage or leakage. Helicopters service drilling rigs, production platforms, and pipeline terminals, as well as specialized vessels such as jack-up barges. The OCS activity levels and offshore oil and gas industry transportation needs substantially influence the demand for and profitability of helicopter services (Dismukes, in preparation-b). A service base may support one or more of these activities, while an offshore facility may utilize one service base for all three uses or different service bases for each. Because of changing weather or operational conditions, small amounts of vessel and helicopter traffic may be dispatched from alternative bases. However, such shifts are expected to be only temporary and vessel traffic and helicopter transport generally returns to primary and secondary bases as soon as possible.

As OCS operations have progressively moved into deeper waters, larger vessels with deeper drafts have been phased into service, mainly for their greater range, faster speed, and larger carrying capacity. Service bases with the greatest appeal for deepwater activity have several common characteristics: strong and reliable transportation systems; adequate depth and width of navigation channels; adequate port facilities; existing petroleum industry support infrastructure; location central to OCS deepwater activities; adequate worker population within commuting distance; and insightful strong leadership. Typically, deeper draft service vessels require channels with depths of 20-26 ft (6-8 m).

Port Fourchon is usually the primary service base identified in exploration and development plans for deepwater activities; however, some operator plans identify other bases instead of Port Fourchon for either crew or helicopter use, or as a backup to Port Fourchon. Because of the limited amount of land available at Port Fourchon, the port may face boat docking capacity constraints in the long term. Operators looking to diversify risk from shutdowns (such as those shutdowns after major hurricanes) are also likely to look to other ports. Thus, in the longer term, other deepwater access ports such as Theodore and Mobile, Alabama, and Pascagoula, Mississippi, may also support OCS deepwater activities in the CPA. The majority of deepwater activity to date has been located south of Port Fourchon or southeast of New Orleans. The Agency-funded study, *Fact Book: OCS-Related Energy Infrastructure and Post-Hurricane Impact Assessment* (Dismukes, in preparation-a), should be published in 2011 and includes an in-depth hurricane impact analysis for each type of coastal infrastructure.

CPA Proposed Action Scenario: The proposed action contributes to the continued need for maintenance of existing service bases. However, no new service bases are expected to develop as a direct result of the CPA proposed action.

OCS Program Scenario: Newer geologic trends being exploited by today's operators may lead to development of capability or the relocation of facilities to a new service base along the Texas Gulf Coast during the years 2007-2046.

Navigation Channels

Chapter 4.1.2.9 of the Multisale EIS and Chapter 3.1.2.1 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from navigation channels in the GOM. Navigation channels undergo

maintenance dredging that is essential for sustaining proper water depths to allow ships to move safely through the waterways to ports, services bases, and terminal facilities. In the northern GOM, the existing system of navigation channels is projected to be adequate to allow proper accommodation for vessel traffic that will occur as a result of a single proposed action. The Gulf-to-port channels and the Gulf Intracoastal Waterway (GIWW) that support prospective OCS ports are maintained by regular dredging and are generally sufficiently deep and wide to handle OCS-related traffic (**Figure 3-5**). The COE is the Federal agency responsible for the regulation and oversight of navigable waterways. The maintained depth for each waterway is shown in Table 3-36 of the Multisale EIS. All single lease sales contribute to the level of demand for offshore supply vessel support; hence, they also contribute to the level of vessel traffic that travels through the navigation channels to support facilities. While maintenance dredging is essential for vessels to safely reach support facilities, it is a controversial process because it necessarily occurs in or near environmentally sensitive areas such as valuable wetlands, estuaries, and fisheries (Dismukes, in preparation-b).

CPA Proposed Action Scenario: The proposed action contributes to the continued need for maintenance dredging of existing navigation channels. However, no additional maintenance dredging is expected to be scheduled or new navigation channels are expected to be constructed as a direct result of the CPA proposed action.

OCS Program Scenario: There is no current expectation for new navigation channels to be authorized and constructed during the years 2007-2046 as a direct result of the OCS Program. One major Federal channel, the Mississippi River Gulf Outlet, was taken out of service and sealed with a rock dike in 2009.

3.1.2.2. Gas Processing Plants

Chapter 4.1.2.1.4.2 of the Multisale EIS and Chapter 3.1.2.2 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from gas processing plants and the potential for new facilities and/or expansion at existing facilities in the GOM. As of January 1, 2007, there were 278 gas processing plants in the Gulf States, representing 56 percent of U.S. gas processing capacity (Dismukes, in preparation-a).

Over the past 5 years, there has been a substantial decrease in offshore natural gas production, partially as a result of increasing emphasis on onshore shale gas development, which is less expensive to produce, is closer to consumption sources, and provides larger per well production opportunities and reserve growth. Also, there has been a trend toward more efficient gas processing facilities with greater processing capacities (Dismukes, personal communication, 2010b). In Alabama, Mississippi, and the eastern portion of South Louisiana, plant capacity increased significantly as plant expansions occurred and new larger plants were built in response to offshore production (USDOE, Energy Information Administration, 2006). While natural gas production on the OCS shelf (shallow water) has been rapidly declining, deepwater gas production has been increasing, but not quickly enough to make up the difference. Increasing onshore shale gas development, declining offshore gas production, and the increasing efficiency and capacity of existing gas processing facilities are trends that have combined to lower the need for new gas processing facilities along the Gulf Coast in the past 5 years. Combined with this, existing facilities that were already operating at about 50 percent of capacity prior to the 2005 hurricane season are operating at even lower capacity utilization levels now. Spare capacity at existing facilities should be sufficient to satisfy new gas production for many years, although there remains a slim chance that a new gas processing facility may be needed by the end of the 40-year life of the proposed action (Dismukes, personal communication, 2010b).

CPA Proposed Action Scenario: The BOEMRE projects that 0-1 new gas processing facility may be constructed as a result of the CPA proposed action. However, the likelihood of a new gas processing facility has moved closer to zero and farther from one (Dismukes, personal communication, 2010b).

OCS Program Scenario: Expectations for new gas processing facilities being built during the period 2007-2046 as a direct result of the OCS Program are dependent on long-term market trends that are not easily predicable over the next 40 years. Existing facilities will experience equipment switch-outs or upgrades during this time.

3.1.2.3. Coastal Pipelines

Chapters 3.3.5.8.8 and 4.1.2.1.7 of the Multisale EIS and Chapter 3.1.2.2 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from OCS pipelines in coastal waters (State offshore and inland waters) and coastal onshore areas. The OCS pipelines near shore and onshore may join pipelines carrying production from State waters or territories for transport to processing facilities or to distribution pipelines located farther inland. In the Multisale EIS, this Agency assumed that the majority of new Federal OCS pipelines would connect to the existing pipelines in Federal and State waters and that very few would result in new pipeline landfalls. Therefore, this Agency projected 0-1 pipeline landfalls per lease sale (USDOI, MMS, 2007b). Between the Multisale EIS and the 2009-2012 Supplemental EIS, this Agency tested this assumption by analyzing past lease sale outcomes and determined that it is unlikely that even one pipeline landfall will result from an individual proposed action (USDOI, MMS, 2007d). Oil and gas companies have a strong financial incentive to reduce costs by utilizing the existing mature pipeline network that already exists in the GOM to the fullest extent possible. Economies of scale are a factor in pipeline transportation, and maximization of the amount of product moved through an already existing pipeline decreases the long-term average cost of production. Additional considerations include mitigation costs for any new wetland and environmental impacts and various landowner issues at the landfall point. These are strong incentives to move new production into existing systems and to avoid creating new landfalls (USDOI, MMS, 2007d). Therefore, BOEMRE projects that the majority of new pipelines constructed as a result of a CPA proposed action would connect to the existing pipeline infrastructure. In the rare instance that a new pipeline would need to be constructed, it will likely be because there are no existing pipelines reasonably close and it is more cost effective to construct a pipeline to shore; although for an operator to choose this contingency is thought to be highly unlikely (Dismukes, personal communication, 2010c).

CPA Proposed Action Scenario: The Multisale EIS and the 2009-2012 Supplemental EIS project that 0-1 new landfalls are projected for a CPA proposed action. This scenario projection stands, although the likelihood of a new pipeline landfall has moved closer to zero and farther from one (Dismukes, personal communication, 2010a).

OCS Program Scenario: The Multisale EIS projected that from 2007 to 2046, 80-118 new pipelines were projected to be built in State waters as a result of the OCS Program. Of those pipelines, 32-47 were projected to make landfall. However, the reassessment of this scenario between the Multisale EIS and the 2009-2012 Supplemental EIS resulted in a more conservative projection that even one pipeline landfall as a result of each lease sale during the OCS Program is unlikely (USDOI, MMS, 2007d). Therefore, the OCS Program from 2007 to 2046 is unlikely to result in more than 11 new pipeline landfalls (see also **Chapter 3.1.1.4.1**).

3.1.2.4. Disposal Facilities for Offshore Operations

Chapters 3.3.5.8.7 and 4.1.2.1.6 of the Multisale EIS and Chapter 3.1.2.4 of the 2009-2012 Supplemental EIS describe the coastal impacting factors arising from the infrastructure network needed to manage the spectrum of waste generated by OCS activity and disposal onshore in the GOM. The analyses of coastal infrastructure presented in the Multisale EIS concluded that no new solid-waste facilities would be built as a result of a single lease sale or as a result of the OCS Program. Between the Multisale EIS and the 2009-2012 Supplemental EIS additional research was conducted that further supports past conclusions that existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs (Dismukes et al., 2007). Recently, there is a trend toward incorporating more innovative methods for waste handling in an attempt to reduce the chance of adverse environmental impacts. Some of these innovative methods include hydrocarbon recovery/recycling programs, slurry fracture injection, treating wastes for re-use as road base or levee fill, and segregating waste streams to reduce treatment time and improve oil recovery (Dismukes, in preparation-a).

Before the DWH event, this Agency's analyses indicated that there was an abundance of solid-waste capacity in the GOM region and, thus, it is highly unlikely that any new waste facilities would be constructed. Recent research shows that the volume of OCS waste generated is closely correlated with the level of offshore drilling and production activity (Dismukes, in preparation-a). If offshore activities increase to the extent that a need for more capacity develops, it will probably be met by expansion of

existing facilities. However, it is now unclear whether this will remain true; therefore, more research is needed (Dismukes, personal communication, 2010d). Due to the temporary suspensions (no longer in effect) on deepwater drilling, there has been some reduction in offshore drilling activity. Given this situation, the demand for waste disposal facilities may not be likely to increase. However, at this time, BOEMRE cannot predict how long this temporary interruption will continue or how long it will take for activity levels to recover. Since there is not enough information at this time to draw a solid conclusion, BOEMRE will continue to monitor waste disposal demands and activity in the post-DWH environment. **Chapter 4.1.1.18.4.2** provides a discussion of environmental justice issues related to waste disposal facilities.

CPA Proposed Action Scenario: Existing onshore facilities will continue to be used to dispose of wastes generated offshore. However, no new disposal facilities are expected to be licensed as a direct result of the proposed action.

OCS Program Scenario: There is no current expectation for new onshore waste disposal facilities to be authorized and constructed during the 2007-2046 period as a direct result of the OCS Program. Existing facilities are likely to undergo expansion, but no definitive projections can be made.

Summary

In response to the DWH event, BOEMRE has reexamined the scenario analysis presented in the Multisale EIS and in the 2009-2012 Supplemental EIS. According to the scenario analysis in the 2009-2012 Supplemental EIS, the construction of 0-1 new gas processing facilities and 0-1 new pipeline landfalls would be expected to occur near the end of the 40-year life of a single lease sale. Given the uncertain environment post-DWH, the CPA proposed action is very conservative since the likelihood is diminished further that any new gas processing facility or pipeline landfall would result from a single lease sale (Dismukes, personal communication, 2010a). New information on the DWH event continues to be developed. The BOEMRE recognizes the need for, and is currently conducting continuous monitoring of, changes in infrastructure demands in order to adequately determine scenario projections for current and future environmental assessments.

3.2. Impact-Producing Factors and Scenario—Accidental Events

The NEPA requires Federal agencies to consider potential environmental impacts of a proposed action as part of agency planning and decisionmaking. Actions that could result in impact are analyzed; including those that have a very low probability of occurring, but that the public considers important, are controversial, or may have severe consequences. The accidental events that fall into this category and that are addressed in this section are (1) oil spills, (2) losses of well control, (3) pipeline failures, (4) vessel collisions, and (5) chemical or drilling fluid spills.

The OCS Program pollution-prevention requirements include features such as redundant safety systems, and periodic inspection and testing protocols. Although the likelihood for spills of the magnitude of the DWH event are rare, when they do occur the affects on physical, biological, and socioeconomic resources can be dramatic and potentially severe.

3.2.1. Oil Spills

Oil spills are unplanned, accidental events but their frequency and volume can be estimated from past occurrences. Chapter 4.3.1 of the Multisale EIS analyzes the risk of spills that could occur as a result of activities associated with a CPA proposed action. Chapter 4.3.1.1 of the Multisale EIS discusses spill prevention.

Chapter 4.3.1.2 of the Multisale EIS provides an overview of spill risk analysis including more information about the inputs to the spill scenario and the trajectory and weathering modeling. Chapter 4.3.1.3 of the Multisale EIS discusses past OCS spills. Oil also enters the GOM by pathways and sources other than spills, including natural seeps, permitted discharges, and sources related to human activities; these are discussed in Chapter 4.1.3.4 of the Multisale EIS and in **Chapter 3.1.1.3** of this Supplemental EIS.

Chapter 4.3.1.4 of the Multisale EIS discusses the physical and chemical properties of oil. The properties of the spilled oil can influence the persistence of the spill on the water's surface and the success

of spill cleanup efforts. The fate of oil in the environment depends on many factors, such as the source and composition of the oil, as well as its persistence (NRC, 2003). Persistence can be defined and measured in different ways (Davis et al., 2004), but the National Research Council generally defined persistence as how long oil remains in the environment (NRC, 2003, p. 89). Once oil enters the environment, it begins to change through physical, chemical, and biological weathering processes (NRC, 2003). These processes may interact and affect the properties and persistence of the oil, including the following:

- evaporation (volatilization);
- emulsification (the formation of a mousse);
- dissolution;
- oxidation; and
- transport processes (NRC, 2003; Scholz et al., 1999).

Horizontal transport takes place via spreading, advection, dispersion, and entrainment while vertical transport takes place via dispersion, entrainment, Langmuir circulation, sinking, overwashing, partitioning, and sedimentation (NRC, 2003). The persistence of an oil slick is influenced by the effectiveness of oil-spill-response efforts and affects the resources needed for oil recovery (Davis et al., 2004). The persistence of an oil slick may also affect the severity of environmental impacts.

Crude oils are not a single chemical, but instead are complex mixtures with varied compositions. Thus, the behavior of the oil and the risk the oil poses to natural resources depends on the composition of the specific oil encountered (Michel, 1992). Generally, oils can be divided into three groups of compounds: (1) light-weight; (2) medium-weight; and (3) heavy-weight components.

Of the oil reservoirs sampled in the Gulf of Mexico OCS, the majority fall within the light-weight category, while less than one-quarter are considered medium-weight and a small portion are considered heavy-weight. Oil with an API gravity of 10.0 or less would sink and has not been encountered in the Gulf of Mexico OCS (USDOI, BOEMRE, 2010c).

Heavy-weight oil may persist in the environment longer than the other two types of oil, but the medium-weight components within oil present the greatest risks to organisms because, with the exception of the alkanes, these medium-weight components are persistent, bioavailable, and toxic (Michel, 1992).

An experiment in the North Sea, Deep Spill, indicated that the majority of oil released during a deepwater blowout would quickly rise to the surface and form a slick (Johansen et al., 2001). In such a case, impacts from a deepwater oil spill would occur at the surface where the oil is likely to be mixed into the water and dispersed by wind and waves. The oil would undergo natural physical, chemical, and biological degradation processes including weathering. However, data and observations from the DWH event challenged the previously prevailing thought that most oil from a deepwater blowout would quickly rise to the surface. While analyses are in their preliminary stages, it appears that measurable amounts of hydrocarbons (dispersed or otherwise) are being detected in the water column as subsurface plumes (**Chapter 4.2.1.2.2.1**) and perhaps on the seafloor in the vicinity of the release. After the *Ixtoc* blowout in 1979, which was located 50 mi (80 km) offshore in the Bay of Campeche, Mexico, some subsurface oil also was observed dispersed within the water column (Boehm and Fiest, 1982); however, the scientific investigations were limited (Reible, 2010).

As spill size increases, the occurrence rate decreases and so does the number of spills estimated to occur (**Table 3-5**) (also see Anderson and LaBelle, 2000). In general terms, coastal waters adjacent to the CPA are expected to be impacted by many frequent small spills (≤1 bbl); few, infrequent, moderately-sized spills (>1 and <1,000 bbl); and rarely a large spill (≥1,000 bbl) as a result of activities associated with the CPA proposed action.

The following discussion provides separate risk information for offshore spills ≥1,000 bbl, offshore spills <1,000 bbl, and coastal spills that may result from the proposed action.

Past Spill Projections and Future Trends

Comments on prior EIS's questioned the validation between the actual number of spills that resulted from a proposed lease sale to the projected number of spills in the NEPA document. This Agency has not performed this validation. When spills are reported to USCG, the location of the spill, the type of vessel, and the volume and the material spilled is identified. The USCG does not attribute a spill back to a BOEMRE lease sale. More information is available about the larger spills than the small spills, and some of them can be matched with a particular lease sale. In other cases, it is more difficult to nearly impossible to link a spill to a lease sale because, for example, a fuel spill could occur from a vessel that services multiple facilities leased during different sales, or a pipeline spill could release oil combined from multiple production locations that were leased during different sales. Many of the small spills do not have a known source and so cannot be linked to a lease sale. An attempt was made in Canada to determine the accuracy of the predicted oil spills from several projects (Fraser and Ellis, 2008). In their investigation of spills of <50 bbl from projects in Nova Scotia and Newfoundland, they found that predicted spills underestimated the number of observed spills.

The U.S. consumption of oil is predicted to rise. The percentage of oil imported has been rising over time. Most imports, with the exception of Canadian oil, are transported by vessel. Fifty-three percent of oil imports, the majority as crude oil, arrive via the Gulf Coast (Ramseur, 2010). Nationally, of the oil spills in coastal and marine areas that are within USCG jurisdiction, 50 percent of both the incidents and the volume spilled occur in the GOM and its shoreline states, making the Gulf Coast an area of concentrated use.

The decline in spill incidents is attributable to implementation of the Act to Prevent Pollution from Ships. This Act reflects U.S. implementation of Annex I of the 1973 International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1987 (MARPOL 73/78), which requires vessels to have equipment that minimizes oil discharges, such as oil-water separators, and a shipboard oil-pollution emergency plan. The decline in spill volume is attributable to a decline in volume spills by oil tankers and barges regulated by the OPA, which increased liability (Ramseur, 2010).

3.2.1.1. Risk Analysis for Offshore Spills ≥1,000 bbl

Methods

Chapter 4.3.1.5 of the Multisale EIS addresses the risk of offshore spills ≥1,000 bbl that could occur from accidents associated with activities resulting from a proposed action. Spill rates (Table 4-16 of the Multisale EIS) were calculated based on the assumption that spills occur in direct proportion to the volume of oil handled and are expressed as number of spills per billion barrels of oil handled. Anderson and LaBelle (2000) provide more information on OCS spill-rate methodologies and trends. A discussion of how the range of resource estimates was developed is provided in Chapter 4.1.1.1 of the Multisale EIS and in **Chapter 3.1.1** of this Supplemental EIS. In addition, BOEMRE is in the process of updating these spill rates, which will include the recent DWH event; however, significant changes to the spill rates for the entire OCS are not anticipated (Anderson, written communication, 2010).

The mean number of future offshore spills ≥1,000 bbl is calculated by multiplying the spill occurrence rate for spills ≥1,000 bbl (1.51) by the volume of oil estimated to be produced as a result of the proposed action (Anderson and LaBelle, 2000). The median size of spills ≥1,000 bbl that occurred during 1985-1999 is 4,551 bbl, and the median size for spills ≥10,000 bbl is 15,000 bbl (Table 4-16 of the Multisale EIS).

Estimates of Spill Numbers

As shown on **Table 3-5,** the mean number of spills estimated for the CPA proposed action is 1-3 spills ≥1,000 bbl.

Fate

Offshore spills ≥1,000 bbl are the most likely to persist long enough on the water's surface to impact the shoreline. The fate of an oil spill is influenced by many variables. Aspects that influence spill

persistence are discussed in Chapter 4.3.2.5.4 of the Multisale EIS and in **Chapter 3.2.1** of this Supplemental EIS, as related to oil type, and they are summarized below (see also **Table 3-6**).

Table 4-37 of the Multisale EIS provides a mass balance over time for a hypothetical spill related to a CPA proposed action, respectively, which are considered in this Supplemental EIS. Weathering processes include evaporation of volatile hydrocarbons into the atmosphere, dissolution of soluble components, dispersion of oil droplets into the water column, emulsification and spreading of the slick on the surface of the water, chemo- or photooxidation, biodegradation, and in some cases sedimentation (sinking) (ITOPF, 2010a; NRC, 2003).

Over time, if the slick is not completely dissipated, a tar-like residue may be left; this residue breaks up into smaller tar lumps or tarballs that usually sink below the sea surface but not necessarily to the seafloor. Not all oils form tarballs.

The BOEMRE used the SINTEF model to numerically model weathering processes (Prentki et al., 2004). Model results from the SINTEF weathering model for the CPA are presented in Table 4-36 of the Multisale EIS.

Movement into the deep waters of the Gulf of Mexico increasingly relies on subsea production infrastructure, possibly increasing the risk of seafloor releases. As noted in **Chapter 3.2.1**, the behavior of a spill depends on many things, including the characteristics of the oil being spilled as well as oceanographic and meteorological conditions. An experiment in the North Sea indicated that the majority of oil released during a deepwater blowout would quickly rise to the surface and form a slick (Johansen et al., 2001). In such a case, impacts from a deepwater oil spill would occur at the surface where the oil is likely to be mixed into the water and dispersed by wind and waves. The oil would undergo natural physical, chemical, and biological degradation processes including weathering. However, data and observations from the DWH event challenged the previously prevailing thought that most oil from a deepwater blowout would quickly rise to the surface. While analyses are in their preliminary stages, it appears that measurable amounts of hydrocarbons (dispersed or otherwise) were detected in the water column as subsurface plumes (**Chapter 4.2.1.2.2.1**) and perhaps on the seafloor in the vicinity of the release. After the *Ixtoc* blowout in 1979, which was located 50 mi (80 km) offshore in the Bay of Campeche, Mexico, some subsurface oil also was observed dispersed within the water column (Boehm and Fiest, 1982); however, the scientific investigations were limited (Reible, 2010). The water quality of marine waters would be affected by the dissolved components and oil droplets that are small enough so that they do not rise to the surface or are mixed downward by surface turbulence. Subsurface oil plumes would be affected by subsurface currents and could be diluted over time. Even in the subsurface, oil would undergo natural physical, chemical, and biological degradation processes including weathering.

Chapter 4.3.1.5.6 of the Multisale EIS provides an estimate of the length of coastline affected by offshore spills ≥1,000 bbl. The maximum length of shoreline affected by a CPA representative spill ≥1,000 bbl is estimated to be 50 km (31 mi) of shoreline, assuming such a spill were to reach land within 12 hours (Table 4-36 of the Multisale EIS). Some oil could become redistributed because of longshore currents, and further smearing of the slick from its original landfall could also occur.

Likelihood of Occurring and Contacting Environmental Resources

The BOEMRE uses the Oil Spill Risk Analysis (OSRA) model to estimate the likely trajectories of hypothetical offshore spills ≥1,000 bbl. The trajectories, combined with estimated spill occurrence, are used to estimate the risk of future spills occurring and contacting environmental features. Chapter 4.3.1.5.5 of the Multisale EIS briefly summarized the OSRA model, while Ji et al. (2007) provides a detailed description of the OSRA model. The probability of spill occurring as a result of the proposed CPA action and contacting environmental resources of concern is provided in Figures 4-14 through 4-31 of the Multisale EIS.

All proposed GOM sales for the 5-Year Program were considered in the OSRA run for the Multisale EIS. The scenario for the CPA proposed action has been revised and is discussed in **Chapter 3.1.1**. A new OSRA run based on just the last CPA proposed lease sale in this Supplemental EIS scenario would not be expected to substantially affect probabilities in comparison with those obtained from the previous OSRA run.

Summary of the Catastrophic Spill OSRA Run

After the DWH event, BOEMRE worked to develop an OSRA model run to adequately assess a hypothetical oil spill that spills continuously at a fixed rate from an assigned location over an assigned duration. Preliminary model runs were conducted to track oil-spill trajectories for 90 days in order to simulate a long-duration spill from a given point. The model tracked the oil-spill trajectories throughout the 90 days (simulated spilling) and stopped the spill after the 90th day to simulate the point at which well control was reestablished and after an additional 30 days after capping to simulate the behavior of oil at sea.

The probability estimates for land contact were tabulated as 90-day groupings corresponding to each quarter of a year (Q1, Q2, Q3, and Q4). These 3-month probabilities can be used to estimate the average number of land segments contacted during a spill event within the designated quarter. The groupings by quarter capture the differences in meteorological and oceanographic conditions in the GOM as they vary over the years from 1993 to 1998 (the most recent GOM data available to BOEMRE). Five launch points were selected for five independent model runs to assess the probably of oil contacting the shoreline from each given hypothetical launch point. The five launch points for the simulated spill corresponded to the following OCS areas in the WPA and CPA:

- LP1—CPA shelf area, west of the Mississippi River Delta, offshore south-central Louisiana, deepwater;
- LP2—CPA shelf edge area, east of the Mississippi River Delta, south of the Alabama-Mississippi border, deepwater;
- LP3—CPA slope area, west of the Mississippi River Delta, due south of New Orleans, ultra-deepwater;
- LP4—WPA shelf area, deepwater; and
- LP5—WPA slope area, ultra-deepwater.

The following first-order results were obtained for a spill of 90 days duration:

- LP1—moderate probability of contacting coastal parishes in south-central Louisiana to counties in north-central Gulf Coast Texas during all quarters of the year, greatest probability in Q3 and Q4;
- LP2—moderate to large probability of contacting Mississippi delta and coastal counties of Alabama and Mississippi in all quarters, greatest probability in Q1, Q2 and Q4;
- LP3—small probability of contacting parishes in east-central Louisiana, greatest probability in Q2;
- LP4—moderately-large probability of contacting the counties of south-central Gulf Coast Texas, greatest probability in Q2; and
- LP5—small probability of a spill contacting the coastal counties of mid-Gulf Coast Texas, greatest probability in Q2.

This exercise is a first of its kind because, although this Agency's OSRA model accounts for an instantaneous spill, it was not designed specifically to model a spill over a given duration. This approach is still under review and development. Preliminary model runs were conducted and only preliminary data are currently available; however, this effort will continue to be developed and advanced to ensure that the most conservative estimates of environmental impacts are available and that all impacts are disclosed. **Appendix C** contains a greater explanation of the catastrophic spill OSRA run.

3.2.1.2. Risk Analysis for Offshore Spills <1,000 bbl

A description of accidental events, including offshore spills <1,000 bbl can be found in Chapter 4.3.1.6 of the Multisale EIS and in Chapter 3.2.1.2 of the 2009-2012 Supplemental EIS. The following information describes spills <1,000 bbl. To discuss spills <1,000 bbl, information is broken into size groups, as shown in Table 4-16 of the Multisale EIS.

Analysis of historical data shows that most offshore OCS oil spills have been ≤1 bbl (Figure 4-32 of the Multisale EIS). Although spills of ≤1 bbl have made up 94 percent of all OCS-related spill occurrences, spills of this size have contributed very little (5%) to the total volume of OCS oil that has been spilled. Most of the total volume of OCS oil spilled (95%) has been from spills ≥10 bbl.

The number of offshore spills <1,000 bbl estimated to occur over the next 40 years as a result of the proposed action is provided in **Table 3-5**, which has been updated from Table 4-35 of the Multisale EIS and from Table 3-6 of the 2009-2012 Supplemental EIS. The number of spills is estimated by multiplying the oil-spill rate for each of the different spill size groups by the projected oil production as a result of the proposed action. The number of spills >500 and <1,000 bbl estimated to occur is <1 to 1 for the CPA proposed action. In the spill size range of >50-500 bbl, 5-11 spills are estimated to occur from activities related to the CPA proposed action. Multiplying the estimated number of spills by the median or average spill sizes for each size group yields the volume of oil estimated to be spilled as a result of the proposed action over the 40-year analysis period. A total of 1,070-2,920 bbl of oil is estimated from spills <1,000 bbl in size as a result of the CPA proposed action.

3.2.1.3. Risk Analysis for Coastal Spills

Chapter 4.3.1.7 of the Multisale EIS addresses the risk of coastal spills of all sizes that could occur from accidents associated with activities resulting from a proposed action. Chapter 3.2.1.3 of the 2009-2012 Supplemental EIS provides an update to the Multisale EIS.

Spills in coastal waters could occur as a result of transportation and handling of OCS-produced oil as it passes through State waters and along navigation channels, rivers, and through coastal bays. The BOEMRE projects that almost all (>99%) oil produced in waters <800 ft (244 m) deep as a result of the proposed action will be brought ashore by pipelines, while 50-100 percent of oil produced in waters >800 ft (244 m) deep will be brought ashore by tanker. Because piped oil is commingled at shore bases and cannot be directly attributed to a particular lease sale, this analysis of coastal spills addresses spills that could occur prior to the oil arriving at the initial shoreline facility. It is also possible that non-OCS oil may be commingled with OCS oil at these facilities or during subsequent secondary transport.

The coastal spill rate is based on historical spills and the projected amount of oil production. Because the majority of oil production from the CPA proposed action is projected to be brought to shore in eastern Louisiana, from Atchafalaya Bay to east of the Mississippi River, it is assumed the majority of coastal spills from the CPA proposed action will also occur in this area.

Several USCG resources were used to estimate the number of coastal oil spills attributable to the proposed action, including the USCG Polluting Incident Compendium and data obtained directly from USCG. The Multisale EIS used a version of the Oil Spill Compendium containing data through 2000, and the 2009-2012 Supplemental EIS used a version of the Oil Spill Compendium containing data through 2004. At present, *Polluting Incidents In and Around U.S. Waters, A Spill/Release Compendium: 1969-2008* is available (U.S. Dept. of Homeland Security, CG, 2010a). The database available from USCG covers through 2008 as well. **Figure 3-6** illustrates, for the year 2008, the location and size range of the spills in both coastal and offshore areas of the CPA.

The number of GOM coastal spills from eight sources associated with State or Federal offshore production and international importation was determined. The sources that were counted are (1) fixed platforms, (2) mobile offshore drilling units, (3) offshore marine facilities, (4) offshore supply/service vessels, (5) offshore pipelines, (6) tank barges, (7) tank ships, and (8) unknown sources. In 2001, a total of 270 spills occurred in coastal GOM, of which roughly half were from the source types associated with State or Federal offshore oil production, oil importation, and unknown sources. All spills of unknown origin were counted as OCS in origin, which would not be the case in reality. Three billion barrels of total oil, including condensate, was transported to shore from Federal and State offshore production and by importation. Federal OCS production comprised 19 percent of the oil transported to the coast and,

therefore, is assumed to account for 19 percent of the spills. The amounts of various fuel oils transported for the purpose of consumption are not counted in this volume. Thus, the OCS production spill rate in coastal waters was determined to be in the range of 57-74 spills per billion barrels of oil.

CPA Proposed Action Scenario: The volume of oil production projected has been updated (**Table 3-1**) to 0.801-1.624 BBO. Given an estimated spill rate of 57-74 spills per billion barrels of oil, it is estimated that 49-126 spills of OCS oil will occur in the CPA coastal area (**Table 3-7**).

OCS Program Scenario: The OCS Program scenario remains the same as the originally forecasted program scenario in the Multisale EIS. Table 4-1 of the Multisale EIS shows the estimated range of the volume of oil production projected.

3.2.1.4. Risk Analysis by Resource

Chapter 4.3.1.8 of the Multisale EIS summarizes this Agency's information on the risk to resources from oil spills and oil slicks that could occur as a result of a CPA proposed action. The risk results are based on BOEMRE's estimates of likely spill locations, sources, sizes, frequency of occurrence, and probable transport. For offshore spills, the analysis presents combined probabilities, which include both the likelihood of a spill from the proposed action, as defined in the Multisale EIS, occurring and the likelihood of the oil slick reaching areas where known environmental resources occur. The analysis of the likelihood of direct exposure and interaction of a resource with an oil slick and the sensitivity of a resource to the oil is provided for environmental and socioeconomic resources in **Chapter 4** of this Supplemental EIS. The coastal spill risk is estimated based on the historic spill rate.(Chapter 4.3.1.7.1 of the Multisale EIS).

3.2.1.5. Spill Response

3.2.1.5.1. BOEMRE Spill-Response Requirements and Initiatives

As a result of the Oil Pollution Act of 1990, BOEMRE was tasked with a number of oil-spill-response duties and planning requirements. According to BOEMRE's regulations at 30 CFR parts 250 and 254, BOEMRE implements these requirements as follows:

- requires immediate notification for spills >1 bbl—all spills require notification to USCG and BOEMRE receives notification from the USCG of all spills ≤1 bbl;
- conducts investigations to determine the cause of a spill;
- assesses civil and criminal penalties, if needed;
- oversees spill source control and abatement operations by industry;
- sets requirements and reviews and approves oil-spill-response plans for offshore facilities;
- conducts unannounced drills to ensure compliance with oil-spill-response plans;
- requires operators to ensure that their spill-response operating and management teams receive appropriate spill-response training;
- conducts inspections of oil-spill-response equipment;
- requires industry to show financial responsibility to respond to possible spills; and
- provides research leadership to improve the capabilities for detecting and responding to an oil spill in the marine environment.

The BOEMRE also issued NTL's and guidance documents that clarify additional oil-spill requirements after the DWH event occurred. Specifics of the DWH event are more fully described within **Appendix D**. The spill-response-related NTL's and guidance documents issued by BOEMRE include the following NTL's.

NTL 2010-N10 "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources"

This NTL, effective November 8, 2010, applies only to operators conducting operations using subsea or surface BOP's on floating facilities. It explains that lessees and operators submit a statement signed by an authorized company official with each application for a well permit indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations at 75 FR 63346. The NTL also informs lessees that BOEMRE will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. The NTL notifies the operator that BOEMRE intends to evaluate the adequacy of each operator to comply in the operator's current Oil Spill Response Plans (OSRP); therefore, there is an incentive for voluntary compliance. The NTL lists the type of information that BOEMRE will review as follows:

- subsea containment and capture equipment, including containment domes and capping stacks;
- subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment;
- riser systems;
- remotely operated vehicles;
- capture vessels;
- support vessels; and
- storage facilities.

NTL 2010-N06 "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS"

This NTL, effective June 18, 2010, explains the procedures for the lessee or operator to submit supplemental information for new or previously submitted EP's, DPP's, or DOCD's. The required supplemental information includes the following: (1) a description of the blowout scenario as required by 30 CFR 250.213(g) and 250.243(h); (2) a description of their assumptions and calculations used in determining the volume of the worst-case discharge required by 30 CFR 250.219(a)(2)(iv) (for EP's) or 30 CFR 250.250(a)(2)(iv) (for DPP's and DOCD's); and (3) a description of the measures proposed that would enhance the ability to prevent a blowout, to reduce the likelihood of a blowout, and to conduct effective and early intervention in the event of a blowout, including the arrangements for drilling relief wells and any other measures proposed. The early intervention methods of the third requirement could actually include the surface and subsea containment resources that BOEMRE announced in NTL 2010-N10, which states that BOEMRE will begin reviewing to ensure that the measures are adequate to promptly respond to a blowout or other loss of well control.

On December 13, 2010, BOEMRE issued a press release and a guidance document to provide a clear path forward for the safe resumption of deepwater drilling operations (USDOI, BOEMRE, 2010d). This guidance clarifies, in part, that although operators are not required to amend their OSRP's to include additional subsea containment information, they may do so voluntarily. The guidance further indicates that BOEMRE will review for the following specific information relating to subsea containment, in addition to that listed in NTL 2010-N10:

- source abatement through direct intervention;
- relief wells;
- debris removal; and

- if a capping stack is the single containment option offered, the operator must provide the reasons that the well design is sufficient to allow shut-in without broach to the seafloor.

An operator can comply with this guidance by submitting a Containment Plan as part of their OSRP. In evaluating the sufficiency of subsea containment information submitted by an operator, BOEMRE will examine the Mudline Shut-in Pressure for the proposed well. The BOEMRE will also evaluate factors such as debris removal from the site.

3.2.1.5.2. Offshore Response and Cleanup Technology

In the event of a spill, particularly a loss of well control, there is no single method of containment and removal that would be 100 percent effective. Spill cleanup is a complex and evolving technology. There are many situations and environmental conditions that necessitate different approaches. New technologies constantly evolve, but they provide only incremental benefits. Each new tool then becomes part of the spill-response tool kit. Each spill-response technique/tool has its specific uses and benefits (Fingas, 1995). Removal and containment efforts to respond to an ongoing spill offshore would likely require multiple technologies, including source containment, mechanical cleanup, in-situ burning of the slick, and chemical dispersants (**Table 3-8**). Even with the deployment of all of these spill-response technologies, it is likely that, with the operating limitations of today's spill-response technology, not all of the oil can be contained and removed offshore.

Because no single spill-response method is 100 percent effective, it is likely that larger spills under the right conditions will require the simultaneous use of all available cleanup methods (i.e., source containment, mechanical cleanup, dispersant application, and in-situ burning). Accordingly, the response to the DWH event employed all of these options simultaneously. The cleanup technique chosen for a spill response will vary depending upon the unique aspects of each situation. The selected mix of countermeasures will depend upon the shoreline and natural resources that may be impacted; the size, location, and type of oil spilled; weather; and other variables. The overall objective of on-water recovery is to minimize the risk of impact by preventing the spread of free-floating oil. The physical and chemical properties of crude oil can greatly affect the effectiveness of containment and recovery equipment, dispersant application, and in-situ burning. It is expected that oil found in the majority of the proposed lease sale areas could range from medium weight oil to condensate. The variety of standard cleanup protocols that were used for removing DWH oil from beaches, shorelines, and offshore water are identified in **Chapter 3.2.1.5.4.**

Most oil-spill-response strategies and equipment are based upon the simple principle that oil floats. However, as evident during the DWH event, this is not always true. Sometimes it floats and sometimes it suspends within the water column or sinks to the seafloor. Oil suspended in the water column and moving with the currents is difficult to track, and therefore recover, using standard visual survey methods (Coastal Response Research Center, 2007).

The National Commission on the British Petroleum (BP) *Deepwater Horizon* Oil Spill and Offshore Drilling's staff working paper 7 (Oil Spill Commission, 2011a), entitled "Response/Clean-Up Technology Research & Development and the BP Deepwater Horizon Oil Spill," has initially indicated that, since the *Exxon Valdez* spill occurred, both the industry and government have underfunded spill-response research and development and, as a result, cleanup technology used during the DWH event was outdated and inadequate. This draft report also makes the recommendation that the Commission consider the fact that future improvements in spill prevention and source containment should not replace the need to provide incentives and funding for spill-response research and development for slick containment and removal, in part, because an exclusive focus on prevention and subsea containment is not an in-depth defense to an oil spill and it would preclude a valuable redundancy in response capability. As a result of this report, the Commission is presently considering various measures that could serve to advance improvements in the present-day, spill-response technology (Oil Spill Commission, 2011a).

Source Containment

To address the new improved containment systems' expectations to rapidly contain a spill as a result of a loss of well control from a subsea well addressed in NTL 2010 N-10, several oil and gas industry majors initiated the development of a new, rapid response system. This system is designed to fully contain oil flow in the event of a potential future underwater blowout and to address a variety of scenarios. The system would consist of specially designed equipment constructed, tested, and available for rapid response. It is envisioned that this system could be fully operational within days to weeks after a spill event occurs. The system is designed to operate in up to 10,000-ft (3,048-m) water depth and adds containment capability of 100,000 bbl of oil/day (4.2 million gallons/day). This new $1 billion investment can be expanded and adapted for new technologies. This equipment should be available by the end of 2011 or by early 2012. The companies that originated this system are forming a nonprofit organization, the Marine Well Containment Company (MWCC), to operate and maintain the system (MWCC, 2010a). The MWCC will provide fully trained crews to operate the system, will ensure the equipment is operational and ready for rapid response, and will conduct research on new containment technologies. At present, MWCC plans to offer this equipment to member companies and to rent it to nonmember companies. Until this equipment is available, industry has worked out a deal with BP to utilize the subsea containment equipment purpose built for the DWH event response (MWCC, 2010b). It is anticipated that this equipment will be available by early 2011.

Another option for source control and containment is through the use of the equipment stockpiled by Helix Energy Solutions Group, Inc (Driver, 2010). The Helix initiative involves more than 20 smaller energy companies and supplements the MWCC response effort. Helix has stockpiled the equipment that it found useful in the DWH event response and is offering it to oil and gas producers for use. This system focuses on three vessels—the *Helix Producer I*, the *Q4000*, and the *Express* deepwater construction vessel, all of which played a role in the DWH event response and which continually work in the GOM. Together, the ships and related equipment can accommodate up to 55,000 bbl of oil/day, 70,000 bbl of liquid natural gas, and 95 MMcf of natural gas at depths up to 8,000 ft (2,438 m). In January 2011, the Helix system will provide only capping capability; however, cap and flow capability is supposed to be online by Spring 2011.

Mechanical Cleanup

Generally, mechanical containment and recovery is the primary oil-spill-response method used (33 CFR 153.305(a)). Mechanical recovery is the process of using booms and skimmers to pick up oil from the water surface. It is expected that the oil-spill-response equipment needed to respond to an offshore spill in the proposed CPA sale area could be called out from one or more of the following oil-spill equipment base locations: Corpus Christi, Aransas Pass, Houston, La Porte, Ingleside, Port Arthur, and Galveston, Texas; Lake Charles, New Iberia, Belle Chase, Cameron, Cocodrie, Morgan City, New Orleans, Sulphur, Houma, Fourchon, Fort Jackson, and Venice, Louisiana; Pascagoula, Mississippi; Theodore and Mobile, Alabama; or Pensacola, Fort Lauderdale, Panama City, and Tampa, Florida. Response times for any of this equipment would vary, dependent on the location of the equipment, the staging area, and the spill site; and on the transport requirements for the type of equipment procured. It is anticipated that equipment would be procured from the closest available oil-spill equipment bases.

In rough seas, a large spill of low viscosity oil, such as a light or medium crude oil, can be scattered over many square kilometers within just a few hours. Oil recovery systems typically have swath widths of only a few meters and move at slow speeds while recovering oil. Therefore, even if this equipment can become operational within a few hours, it would not be feasible for them to encounter more than a fraction of a widely spread slick (ITOPF, 2010b). For this reason, it is assumed that a maximum of 10-30 percent of an oil spill in an offshore environment can be mechanically removed from the water prior to the spill making landfall (U.S. Congress, Office of Technology Assessment, 1990). Some newer oil skimming equipment procured internationally displayed faster recovery speed during the response to the DWH event, and some changes were also made in the logistics of how skimmers and booms were positioned offshore during this response that increased the equipment's swath width. However, for the DWH event, it was estimated that only 3 percent of the total oil spilled was picked up by mechanical equipment offshore (Lubchenco et al., 2010).

A common difficulty when deploying booms and skimmers to recover oil is coordinating vessel activities to work the thickest areas of oil (ITOPF, 2010b). It is a rule of thumb that 90 percent of the oil is in 10 percent of the area. The 10 percent of the oil that makes up 90 percent of a slick is typically sheen. For this reason, containment and recovery operations on water require extensive logistical support to direct the response effort. Additionally, the limitations that poor weather and rough seas impose on spill-response operations offshore are seldom fully appreciated. Handling wet, oily, slippery equipment on vessels that are pitching and rolling is difficult and can raise safety considerations. Winds, wave action, and currents can drastically reduce the ability of a boom to contain and a skimmer to recover oil. It is important to select equipment for a response that is suitable for the type of oil and the prevailing weather and sea conditions for a region. Efforts should generally be made to target the heaviest oil concentrations and areas where collection and removal of the oil will reduce the likelihood of oil reaching sensitive resources and shorelines. As oil weathers and increases in viscosity, cleanup techniques and equipment should be reevaluated and modified (ITOPF, 2010b).

Practical limitations of strength, water drag, and weight mean that generally only relatively short lengths of boom (tens to a few hundred meters) can be deployed and maintained in a working configuration. Towing booms at sea (e.g., in U or J configurations, which increase a skimmers swath width) is a difficult task requiring specialized vessels and trained personnel (ITOPF, 2010b). Additional boom limitations are discussed in **Chapter 3.2.1.5.4**. Because skimmers float on the water surface, they experience many of the operational difficulties that apply to booms, particularly those posed by wind, waves, and currents (ITOPF, 2010b). The effectiveness of any skimmer depends upon a number of factors, in addition to the ambient weather and sea conditions, including the type of oil, the thickness of the oil, the presence of debris in the oil or in the water, and the location of the spill (Fingas, 1995). Even moderate wave motion can greatly reduce the effectiveness of most skimmer designs (ITOPF, 2010b). In high sea-state conditions, many skimmers, especially weir and suction skimmers, take up more water than oil (Fingas, 1995). Because of the various constraints placed upon skimmers in the field, their design capacities are rarely realized. Experience from numerous spills has consistently shown that skimmer recovery rates reported under test conditions cannot be sustained during a spill response (ITOPF, 2010b). The availability of sufficient oil-storage facilities is necessary to ensure continuous oil-spill recovery. This storage needs to be easy to handle and easy to empty once full so that it can be used repeatedly with the least interruption in recovery activity (ITOPF, 2010b).

There are no proven methods for the containment of submerged oil, and methods for recovery of submerged oils have limited effectiveness. Efforts to mechanically contain and/or recover suspended oil have focused on different types of nets, either the ad hoc use of fishing nets or specially designed trawl nets. There has been some research conducted on the design of trawl nets for the recovery of emulsified fuels. However, the overall effectiveness for large spills is expected to be very low. The suspended oil can occur as liquid droplets or semisolid masses in sizes ranging from millimeters to meters in diameter (Coastal Response Research Center, 2007).

If an oil spill occurs during a storm, spill response from shore would occur following the storm. Spill response would not be possible while storm conditions continued, given the sea-state limitations for skimming vessels and containment boom deployment. However, oil released onto the ocean surface during a storm event would be subject to accelerated rates of weathering and dissolution (i.e., oil and water would be agitated, forcing oil into smaller droplets and facilitating dissolution of the high end aromatic compounds present).

Dispersants

When dispersants are applied to spilled crude oil, the surface tension of the oil is reduced, allowing wind and wave action to break the oil into tiny droplets that are dispersed into the upper portion of the water column. Oil that is chemically dispersed at the surface will move into the top 20 ft (6 m) of the water column where it will mix with surrounding waters and begin to biodegrade (U.S. Congress, Office of Technology Assessment, 1990, p. 19). Dispersant use, in combination with natural processes, breaks up the oil into smaller components that allows them to dissipate into the water and degrade more rapidly (Nalco, 2010). Dispersion increases the likelihood that the oil will be biodegraded, both in the water column and at the surface. While there is more analysis to be done to quantify the rate of biodegradation in the GOM after the DWH event, early observations and preliminary research results seemed to indicate

that the oil biodegraded quickly; however, there are still ongoing studies assessing this issue. Bacteria that break down the dispersed and weathered surface oil are abundant in the GOM in large part because of the warm water, the favorable nutrient and oxygen levels, and the fact that oil enters the GOM through natural seeps regularly (Lubchenco et al., 2010).

Dispersant use must be in accordance with the Regional Response Team's (RRT) Preapproved Dispersant Use Manual and with any conditions outlined within a RRT's site-specific, dispersant approval given after a spill event. Consequently, dispersant use would be in accordance with the restrictions for specific water depths, distances from shore, or monitoring requirements. At this time, this manual does not give preapproval for the application of dispersant use subsea. However, USEPA is presently revisiting these RRT preapprovals in light of the dispersant issues, such as subsea application, that arose during the DWH response. For a deepwater (>1,000 ft; >305 m water depth) spill ≥1,000 bbl, dispersant application may be a preferred response in the open-water environment to prevent oil from reaching a coastal area, in addition to mechanical response. However, the window of opportunity for successful dispersant application may be somewhat narrower for some deepwater locations that are dependent upon the physical and chemical properties of oil, which tend to be somewhat heavier than those found closer to shore. A significant reduction in the window of opportunity for dispersant application may render this response option ineffective.

Based on the present location of dispersant stockpiles and dispersant application equipment in the GOM, it is expected that the dispersant application aircraft initially called out for an oil-spill response to an offshore spill in the proposed lease sale area will come from Houma, Louisiana; Stennis, Mississippi; or Coolidge, Arizona. The dispersants will come from locations primarily in Texas and Louisiana. Response times for this equipment would vary, depending on the spill site and on the transport time for additional supplies of dispersants to arrive at a staging location. Based on historic information, this Supplemental EIS assumes that dispersant application will be effective on 20-50 percent (S.L. Ross Environmental Research Ltd., 2000) of the treated oil.

If an oil spill occurs during a storm, the dispersant application would occur following the storm. Aerial and vessel dispersant application would not be possible while storm conditions continued. However, oil released onto the ocean surface during a storm event would be subject to accelerated rates of weathering and dissolution (i.e., oil and water would be agitated, forcing oil into smaller droplets and facilitating dissolution of the high-end aromatic compounds present).

In-situ Burning

In-situ burning is an oil-spill cleanup technique that involves the controlled burning of the oil at or near a spill site. The use of this spill-response technique can provide the potential for the removal of large amounts of oil over an extensive area in less time than other techniques. In-situ burning involves the same oil collection process used in mechanical recovery, except instead of going into a skimmer, the oil is funneled into a fire boom, which is a specialized boom that has been constructed to withstand the high temperatures from burning oil. While in-situ burning is another method for disposing of oil that has been collected in a boom, this method is typically more effective than skimmers when the oil is highly concentrated. In-situ burning was successfully used in 411 burns during the DWH spill response, successfully eliminating between 220,000 and 300,000 bbl of oil from the water surface (Allen, 2010), approximately 5 percent of the Macondo oil spilled (Lubchenco et al., 2010).

Response times for bringing a fire-resistant boom onsite would vary, depending on the location of the equipment, the staging area, and the spill site. If an oil spill occurs during a storm, in-situ burning would occur following the storm. In-situ burning would not be possible while storm conditions continued.

Natural Dispersion

Depending upon environmental conditions and spill size, the best response to a spill may be to allow the natural dispersion of a slick to occur. Natural dispersion may be a preferred option for smaller spills of lighter nonpersistent oils and condensates that form slicks that are too thin to be removed by conventional methods and that are expected to dissipate rapidly, particularly if there are no identified potential impacts to offshore resources and a potential for shoreline impact is not indicated. In addition, natural dispersion may also be a preferred option in some nearshore environments, such as a marsh

habitat, when the potential damage caused by a cleanup effort could cause more damage than the spill itself.

3.2.1.5.3. Oil-Spill-Response Assumptions Used in the Analysis of a Most Likely Spill ≥1,000 bbl Incident Related to the Proposed Action

Tables 4-36 and 4-37 and Chapter 4.3.5.3 of the Multisale EIS present the estimated amounts of oil that will either be removed by the application of dispersants or mechanically recovered for the 4,600-bbl pipeline spill scenarios analyzed in the Multisale EIS. The scenarios assumed oils of 30^{o} and 35^{o} API.

3.2.1.5.4. Onshore Response and Cleanup

Offshore response and cleanup is preferable to shoreline cleanup; however, if an oil slick reaches the coastline, it is expected that the specific shoreline cleanup countermeasures identified and prioritized in the appropriate Area Contingency Plans (ACP's) for various habitat types would be used. The sensitivity of the contaminated shoreline is the most important factor in the development of cleanup recommendations. Shorelines of low productivity and biomass can withstand more intrusive cleanup methods such as pressure washing. Shorelines of high productivity and biomass are very sensitive to intrusive cleanup methods and, in many cases, the cleanup is more damaging than allowing natural recovery.

Oil-spill-response planning in the U.S. is accomplished through a mandated set of interrelated plans. The ACP's cover subregional geographic areas and represent the third tier of the National Response Planning System mandated by OPA. The ACP's are a focal point of response planning, providing detailed information on response procedures, priorities, and appropriate countermeasures. The Gulf coastal area that falls within USCG District 8 is covered by the One Gulf Plan ACP, which includes separate Geographic Response Plans for areas covered by USCG Sector Corpus Christi, Sector Houston/Galveston, Sector Port Arthur, Sector Morgan City, Sector New Orleans, and Sector Mobile. The Miami ACP covers the remaining Gulf coastal area. The ACP's are written and maintained by Area Committees assembled from Federal, State, and local governmental agencies that have pollution response authority; nongovernmental participants may attend meetings and provide input. The coastal Area Committees are chaired by respective Federal On-Scene Coordinators from the appropriate USCG Office and are comprised of members from local or area-specific jurisdictions. Response procedures identified within an ACP or its Geographic Response Plan(s) reflect the priorities and procedures agreed to by members of the Area Committees.

If an oil slick reaches the coastline, the responsible party will be required to use the specific shoreline cleanup countermeasures identified and prioritized for the various habitat types potentially impacted in the appropriate ACP's that cover these areas. However, due to the lack of specific and detailed response information in the existing Gulf of Mexico ACP's, the response to the DWH event required that separate, more detailed plans be developed for protection of these shoreline areas after much additional consultation between the Unified Command and local government agencies. The detailed plans developed during the DWH response are being incorporated into the geographic response plans as appropriate for the One Gulf Plan/ACP(s).

The single, most-frequently recommended, spill-response strategy for the areas identified for protection in all of the applicable ACP's or its Geographic Response Plans is the use of a shoreline boom to deflect oil away from coastal resources such as seagrass beds, marinas, resting areas for migratory birds, bird and turtle nesting areas, etc. Since oil spilled at sea tends to move and spread rapidly into very thin layers, boom is deployed to corral the oil on the water to enhance recovery effectiveness of skimmers and other response technologies. Boom is also used to protect shoreline areas and to minimize the consequences of an oil spill reaching shore. There are tradeoffs in deciding where and when to place boom because, once deployed, boom is time consuming to tend and to relocate. For example, booming operations are sensitive to wind, wave, and currents and need to be tethered and secured to keep them from moving. Rough seas can tear, capsize, or shred boom. Currents over 1.5 kn (1.7 mph) or even a wake from a boat can send oil over or under a boom. Untended boom can become a barricade to wildlife and to ship traffic. Boom anchors can damage some habitats. During the DWH event, it was discovered

that hard boom often did more damage in the marsh it was intended to protect than anticipated after weather conditions ended up stranding the boom back into the marsh (USDOC, NOAA, 2010a).

If a shoreline is oiled, the selection of the type of shoreline remediation to be used will depend on the following: (1) the type and amount of oil on the shore; (2) the nature of the affected coastline; (3) the depth of oil penetration into the sediments; (4) the accessibility and the ability of vehicles to travel along the shoreline; (5) the possible ecological damage of the treatment to the shoreline environment; (6) weather conditions; (7) the current state of the oil; and (8) jurisdictional considerations. To determine which cleanup method is most appropriate during a spill response, decisionmakers must asses the severity and nature of the injury using Shoreline Cleanup Assessment Team survey observations. These onsite decisionmakers must also estimate the time it will take for an area to recover in the absence of cleanup (typically considering short term to be 1-3 years, medium term to be 3-5 years, and long term greater than 5 years (National Response Team, 2010).

Shoreline Cleanup Countermeasures

The following assumptions regarding the clean up of spills that contact coastal resources in the area of consideration reflect a generalization of the site-specific guidance provided in the ACP's or its Geographic Response Plans applicable to the GOM. As stated in **Chapter 4.3.1.4**, it is expected that a typical oil spilled as a result of an accident associated with the CPA proposed action would be within the range of 30-35° API. Since the following discussion is intended to address the most likely spill scenario discussed in **Chapter 3.2.1.5.3**, cleanup countermeasures for medium-weight oil are all that are included in the following discussion. The ACP's applicable to the Gulf coastal area cover a vast geographical area. The differences in the response priorities and procedures among the various ACP's or its Geographic Response Plans reflect the differences in the identified resources needing spill protection in the area covered by each ACP or the Geographic Response Plans.

- *Barrier Island/Fine Sand Beaches Cleanup*: After the oiling of a barrier island/fine sand beach with a medium-weight oil, applicable cleanup options are manual removal, trenching (recovery wells), sediment removal, cold-water deluge flooding, shore removal/replacement, and warm-water washing. Other possible shoreline countermeasures include low-pressure cold-water washing, burning, and nutrient enhancement. Responders are requested to avoid the following countermeasures: no action; passive collection (sorbents); high-pressure, cold-water washing; hot-water washing; slurry sand blasting; vacuum; and vegetation cutting.
- *Fresh or Salt Marsh Cleanup*: In all cases, cleanup options that avoid causing additional damage to the marshes will be selected. After the oiling of a fresh or salt marsh with medium-weight oil, a preferred cleanup option would be to take no action. Another applicable alternative would be trenching (recovery wells). Shore removal/replacement, vegetation cutting, or nutrient enhancement could be used. The option of using vegetation cutting as a shoreline countermeasure will depend upon the time of the year and will be considered generally only if the re-oiling of birds is possible. Chemical treatment, burning, and bacterial addition are countermeasures under consideration. Responders are advised to avoid manual removal, passive collection, debris removal/heavy equipment, sediment removal, cold-water flooding, high- or low-pressure cold-water washing, warm-water washing, hot-water washing, slurry sand blasting, and shore removal/replacement.
- *Coarse Sand/Gravel Beaches Cleanup*: After the oiling of coarse sand/gravel beach with medium-weight oil, applicable cleanup options are manual removal, trenching (recovery wells), sediment removal, cold-water deluge flooding, and shore removal/replacement. Other possible shoreline countermeasures include low-pressure, cold-water washing; burning; warm-water washing; and nutrient enhancement. Responders are requested to avoid the following countermeasures: no action; passive collection (sorbents); high-pressure, cold-water washing; hot-water washing; slurry sand blasting; vacuum; and vegetation cutting.

- *Exposed or Sheltered Tidal Flats Cleanup*: After the oiling of an exposed or sheltered tidal flat with medium-weight oil, the preferred cleanup option is no action. Other applicable shoreline countermeasures for this resource include trenching (recovery wells) and cold-water deluge flooding. Other possible shoreline countermeasures listed include low-pressure, cold-water washing; vacuum; vegetation cutting; and nutrient enhancement. Responders are requested to avoid manual removal; passive collection; debris removal/heavy equipment; sediment removal; high-pressure, cold-water washing; warm-water washing; hot-water washing; slurry sand blasting; and shore removal replacement.

- *Seawall/Pier Cleanup*: After the oiling of a seawall or pier with a medium-weight oil, the applicable cleanup options include manual removal; cold-water flooding; low- and high-pressure, cold-water washing; warm-water washing; hot-water washing; slurry sand blasting; vacuum; and shore removal replacement. Other possible shoreline countermeasures listed include burning and nutrient enhancement. Responders are requested to avoid no action, passive collection (sorbents), trenching, sediment removal, and vegetation cutting.

3.2.2. Losses of Well Control

The BOEMRE requires that all losses of well control be reported to BOEMRE. Effective July 17, 2006, this Agency revised the regulations for loss of well control incident reporting, which were further clarified in NTL 2010-N05, "Increased Safety Measures for Energy Development on the OCS," effective June 8, 2010. Operators are required to document any loss of well control event, even if temporary, and the cause of the event by mail or email to the addressee indicated in the NTL. The operator does not have to include kicks that were controlled but should include the release of fluids through a flow diverter (a conduit used to direct fluid flowing from a well away from the drilling rig).

The current definition for loss of well control is as follows:

- uncontrolled flow of formation or other fluids (the flow may be to an exposed formation [an underground blowout] or at the surface [a surface blowout]);
- uncontrolled flow through a diverter; and/or
- uncontrolled flow resulting from a failure of surface equipment or procedures.

Not all loss of well control events result in blowouts; defined as any of the 3 loss of well control events above, but most commonly thought of as a release to the human environment. A loss of well control can occur during any phase of development, i.e., exploratory drilling, development drilling, well completion, production, or workover operations. A loss of well control can occur when improperly balanced well pressure results in sudden, uncontrolled releases of fluids from a wellhead or wellbore (PCCI Marine and Environmental Engineering, 1999; Neal Adams Firefighters, Inc., 1991). From 2006 to 2009, of the 23 loss of well control events reported in the GOM, 6 (26%) resulted in loss of fluids at the surface or underground (USDOI, BOEMRE, 2010e). In addition to spills, the loss of well control can resuspend and disperse bottom sediments. Historically, since 1971, most OCS blowouts have resulted in the release of gas; blowouts resulting in the release of oil have been rare.

The most recent blowout occurred on April 20, 2010, at the Macondo well in Mississippi Canyon Block 252 (DWH event) (**Appendix D**). Although this is statistically a rare event, the blowout resulted in the release of 4.9 million bbl of oil (Lubchenco et al., 2010) and large quantities of gas to the subsea environment. To date, a gas volume release for Macondo has not been officially calculated as a Government estimate, but BOEMRE has made an estimate of 15 Bcf of gas released by Macondo, in absence of any other attempt at quantifying the release (DeCort, personal communication, 2010). A multi-agency Government estimate for the oil released by Macondo was made by Lubchenco et al. (2010) in early August 2010 and has not been revised to date.

Prior to the DWH event, two of the largest spills resulting from blowouts on the Gulf of Mexico OCS occurred in 1970, releasing 30,000 and 40,000 bbl of oil, respectively. Since 1970 there has been a total

of 13 losses of well control events that have resulted in >50 bbl of oil being spilled. Most of these losses of well control were of short duration, more than one-half lasting less than a day (USDOI, BOEMRE, 2010e). In contrast, the DWH event continued uncontained for 87 days, between April 20 and July 15, 2010.

As shown by the DWH event, the loss of well control in deep water has presented obstacles and challenges that would not be encountered during a loss of well control in shallow waters. Although many of the same techniques used for wild well control efforts in shallow water were used to attempt to control the Macondo well, these well control efforts were hindered by water depth, which required reliance solely upon the use of ROV's for all well intervention efforts. This is a concern in deep water because the inability to quickly regain control of a well increases the size of a spill, as occurred during the DWH event. The DWH event required that the operator attempt well-control efforts at the seabed in very deep water depths (over 5,000 ft; 1,524 m), and after the explosions and fire that sunk the *Deepwater Horizon*, key personnel were missing who could have accessed surface switches to shut down the well if a functional BOP was installed.

As indicated by Neal Adams Firefighters, Inc. (1991) and by the DWH event, there are several options that could be attempted to control a well blowout. Common kill techniques include (1) bridging, (2) capping/shut-in, (3) capping/diverting, (4) surface stinger, (5) vertical intervention, (6) offset kill, and (7) relief wells (Neal Adams Firefighters, Inc. 1991). Although much has been learned about well control in deep water as a result of the DWH event, if a deepwater subsea blowout occurs in the future, it is likely that an operator would be required to immediately begin to drill one or more relief wells to gain control of the well. This may be required whether or not this is the first choice for well control because the relief well is typically considered the ultimate final solution for regaining well control in such circumstances.

Although it can take months, the actual amount of time required to drill the relief well depends upon the following: (1) depth of formation below mudline; (2) complexity of the intervention; (3) location of a suitable rig; (4) type of operation that must be terminated in order to release the rig (e.g., may need to complete a casing program before releasing the rig); and (5) any problems mobilizing personnel and equipment to the location.

The major differences between a blowout during the drilling phase versus the completion or workover phases is the drilling well tendency to "bridge off." Bridging is a phenomenon that occurs when severe pressure differentials are imposed at the well/reservoir interface and the formation around the wellbore collapses and seals the well. Deepwater reservoirs are susceptible to collapse under "high draw down" conditions. However, a completed well may not have the same tendency to passively bridge off as would a drilling well involving an uncased hole. Bridging would have a beneficial effect for spill control by slowing or stopping the flow of oil from the well (PCCI Marine and Environmental Engineering, 1999). There is a difference of opinion among blowout specialists regarding the likelihood of deepwater wells bridging naturally in a short period of time. Completed wells, or those in production, present more severe consequences in the event of a blowout due to the hole being fully cased down to the producing formation, which lowers the probability of bridging (PCCI Marine and Environmental Engineering, 1999). Therefore, the potential for a well to bridge is greatly influenced by the phase of a well. See **Chapter 3.2.1.5** for a discussion of planned well-source containment options that were designed to address an ongoing loss of well control event.

In 2007, this Agency (Izon et al., 2007) looked at the occurrences of blowouts during a 15-year period. From 1992 to 2006, 39 blowouts occurred at a rate of one blowout for every 387 wells drilled. These numbers are down from the previous 15-year period where 87 blowouts occurred at a rate of one blowout for every 246 wells drilled. The majority of blowouts (84%) occurred at water depths <500 ft (152 m), which corresponds to where most of the wells in the GOM have been drilled. Forty-one percent of the blowouts lasted 1-7 days, and cementing problems were associated with 18 of the 39 blowouts. Flow diverters, which channel drilling fluid under normal circumstances but during a blowout would channel oil or gas, were used in 20 of the 39 blowouts with success reported in 16 out of 20. The occurrence of loss of well control events has improved over the last 25 years, and most loss of well control events are recoverable onsite and result in no environmental releases. Industry challenges remain as operators move into ultra-deepwater areas and seek deeper geologic prospects with little knowledge of the subsurface environment and with the use of new technologies in both familiar and unfamiliar environments.

Blowout Preventers

A BOP is a device with a complex of choke lines and hydraulic rams mounted atop a wellhead designed to close the wellbore with a sharp horizontal motion that may cut through or pinch shut casing and sever tool strings. Depending on how it is configured, a BOP could weigh 250 tons and cost from $25 to $35 million, and higher. The BOP's were invented in the early 1920's and have been instrumental in ending dangerous, costly, and environmentally damaging oil gushers on land and in water. The BOP's have been required for OCS oil and gas operations from the time offshore drilling began in the late 1940's.

The BOP's are actuated as a last resort upon imminent threat to the integrity of the well or the surface rig. For cased wells, the normal situation, the hydraulic ram may be closed if oil or gas from an underground zone enters the wellbore to destabilize it. By closing a BOP, usually by redundant surface-operated and hydraulic actuators, the drilling crew can prevent explosive pressure release and allow control of the well to be regained by balancing the pressure exerted by a column of drilling mud with formation fluids or gases from below.

Surface BOP's typically differ from subsea BOP's by the reduced redundancy in the stack. This is in part due to the ease of maintenance and repair to the stack at the surface in comparison to the subsea BOP, which may have to be retrieved for these issues. As there are typically less components, the surface BOP stacks are lighter as a result. The differences in typical configuration between surface BOP's and subsea BOP's are shown below, from the top to the bottom of typical BOP stacks.

Subsea BOP	Surface BOP
Upper Annular Preventer	Annular Preventer
Lower annular Preventer	NE
Blind Shear Ram	NE
Upper Pipe Ram	Upper Pipe Ram
Choke Valves	Middle Pipe Ram
Middle Pipe Ram	Choke Valves
Lower Pipe Ram	Lower Pipe Ram
Subsea Isolation Device	NE

NE = no equivalent

Source: MCS Advanced Subsea Engineering (2010, Table 3.2).

Both annular and shear rams are typically configured together in the subsea BOP stack to create redundancy. Because BOP's are important for the safety of the drilling crew, as well as the rig and the wellbore itself, BOP's are regularly inspected, tested, and refurbished. The post-DWH event regulations and inspection program required for BOP's is discussed below and in **Chapter 1.3.1**. Among the changes are new provisions for BOP testing.

The most important components of the BOP for regaining control of a wild well are rams. There are four types of rams: pipe ram; annular preventer; shear ram; and blind shear ram (MCS Advanced Subsea Engineering, 2010, pp. 17-20).

Pipe Ram

A pipe ram is an element that acts as a seal in the BOP. There are rams for high-pressure and low-pressure applications. Pipe rams were historically comprised of two half circles that were designed to seal around the drill pipe; however, there are newer styles of rams that are variable and that fit a range of pipe sizes.

Annular Preventer

The annular preventer is a component of the pressure control system in the BOP that is usually situated at the top of the stack. It is a device that can form a seal in the annular space around any object in the wellbore or upon itself, enabling well control operations to commence. A reinforced elastomer packing element is compressed by hydraulic pressure to affect the seal.

Blind Ram and Blind Shear Ram

A blind ram is used to seal an open hole when there are no tools or drill string in the bore. Blind shear rams have a cutting edge that is designed to shear drill string, casing, or production tubing that may be in the hole, allowing the blind rams to seal the hole. Blind rams are intended to seal against each other to effectively close the hole; they are not intended to seal against any drill pipe or casing.

Subsea Isolation Device

A subsea isolation device allows a well to be sealed below the BOP stack to allow the rig or drillship to move off location in case of an emergency disconnect situation, such as an approaching hurricane. Where there is the need to disconnect from the wellhead in a blowout or other well control situation, a subsea isolation device may be used. The subsea isolation device is placed at the mudline with riser and wellhead connectors set up to allow emergency disconnect if needed. The subsea isolation devices have different names depending on the operator and manufacturer. They can be called a subsea isolation device, environmental safety guard, surface disconnect system, or subsea shut-off device, just to name a few. The subsea isolation device is not designed for typical well control and is not considered a BOP. It is designed to seal the well and disconnect the riser from the seafloor if required, allowing safe well abandonment and the possibility to enter the well at a later point. The subsea isolation devices are typically activated with an acoustic trigger or from an ROV control panel.

Choke Valves

Choke valves are the means of controlling the BOP or subsea isolation device functions. They can either be fixed or adjustable. An adjustable valve has the advantage of allowing more control over fluid control parameters; however, under prolonged use, they may be more susceptible to erosion than fixed valves.

This Agency's role during the efforts to actuate the BOP after the sinking of the DWH event was evaluated in staff working paper 6 for the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling (Oil Spill Commission, 2011b, pp. 4-7). The staff's evaluation described limited supervision by this Agency in the early spill containment effort, but it was in line with [this Agency's] established role in overseeing deepwater drilling in general. The Commission staff attributed this Agency's role to stem from a lack of resources and absence of important operational expertise (Oil Spill Commission, 2011b, pp. 7-8).

Blowout Preventer Effectiveness

The Technology Assessment & Research (TA&R) Program is a research element within BOEMRE's Regulatory Program. The TA&R Program supports research associated with operational safety and pollution prevention, as well as oil-spill response and cleanup capabilities. The TA&R Program was established in the 1970's to ensure that industry operations on the OCS incorporated the use of the best available and safest technologies, subsequently required through the 1978 OCSLA amendments and Energy Policy Act of 2005 (EPAct). The TA&R Program is comprised of three functional research activities: operational safety and engineering research; oil-spill-response research; and renewable energy research. There is no automatic connection between TA&R research outputs and changes to BOEMRE requirements. Management discretion is involved between the research outputs produced by TA&R and how or if they lead to a change in regulation.

The studies carried out by this Agency on the effectiveness of BOP's over the last 12 years have resulted in a mixed assessment of their effectiveness. An unavoidable condition involved in any BOP study to sample unit effectiveness is that a test is destructive for the casing or drill string components elected as representative and is also unique to the conditions under which the test was deployed. Tests should be as realistic as possible of in situ conditions and materials used. As a review of the TA&R studies that have been undertaken shows (below), this is not often the case. This Agency has never required destructive testing; such a program has not been proposed in recent BOEMRE, post-DWH regulations (**Chapter 1.3.1**). Routine destructive testing of equipment like a BOP may diminish its lifespan making such a test program costly.

Another train of assumption that underpins effectiveness testing would be (1) that other BOP units from a manufacturer are assumed to be representative of the same type and design, (2) that units are maintained according to specification, and (3) that all modifications or maintenance for BOP units available for deployment have been carried out under a system of design control and configuration management so that rig crews know that a properly maintained or modified unit is deployed, and so that if a crew has occasion to actuate a BOP in an emergency, they have access to accurate drawings for any modification that may have been made to it. For example, there were apparently modifications made to the Macondo BOP in a maintenance overhaul. The spill response engineers seeking to activate the BOP with ROV's did not understand what modifications had been made and did not have accurate drawings of its modified configuration (Webb, 2010).

Tetrahedron, Inc. (1996) conducted a study using data provided by the oil industry to determine BOP failure rates when tested at 7- and 14-day time intervals. The regulation 30 CFR 250.57 at that time required that a BOP must be tested when

- installed;
- before drilling each string of casing or before continuous operations in cases where the cement is not drilled out; and
- at least once a week, but not exceeding 7 days between pressure tests, alternating between control stations. A period of more than 7 days between BOP tests is allowed when there is a stuck pipe or there are pressure control operations and remedial efforts are being performed, provided that the pressure tests are conducted as soon as possible and before normal operation resumes.

When a unit is deployed on a well site and installed, BOEMRE requires a pressure-up and hold time test for the ram components without actually actuating the rams in the field. Tests succeed or fail on the ability for the system to hold specified pressures at intervals from 3 to 5 minutes. Tetrahedron, Inc. (1996) used the data to look at BOP component failures as well as failure rates between surface BOP's and subsea BOP's. For this study, a test of BOP failure was reported when any piece of equipment had to be physically repaired or sent to the shop for repairs for both initial and subsequent tests. Data was collected from 155 BOP (surface and subsea) tests, from which 63 were reported as failures (41%). When looking at surface versus subsea BOP's, 22 out of 50 surface tests failed (44%) and 12 out of 56 subsea tests failed (21%).

As a result of this study, this Agency proposed a rule change to lengthen the pressure testing interval to not exceed 14 days (*Federal Register*, 1997b) and expanded on how testing was to be carried out for BOP's in general. This Agency concluded that no statistical difference existed in failure rates for BOP's tested between 0- to 7-day intervals and 8- to 14-day intervals (*Federal Register*, 1998, p. 29604). That is to say, the testing interval was not a controlling factor. This Agency, in effect, accepted that whether tested every 7 days or every 14 days, equivalent marginal test results were obtained. The rule was finalized (*Federal Register*, 1998), amending 30 CFR 250.406, 250.407, and 250.516 in line with the proposed changes to expand required BOP testing to the longer interval.

Holand (1999) conducted a study on the reliability of subsea BOP's for deepwater applications reported for 83 wells drilled in the years 1997 and 1998. He looked at the number of days the BOP's were in service and the number of hours lost due to reported BOP failures. The failures were also classified as safety noncritical and safety critical. Safety noncritical failures are failures that occur on the rig during operation and testing of the BOP, whereas safety critical failures occur after testing and during a period in which the BOP is acting as a barrier. There were 117 BOP safety critical failures reported during 4,009 BOP service days, with a total of 3,637.5 hours lost. The failure rate for safety critical systems, the point at which the BOP was preventing a gas or fluid release, was 57 percent. The main cause of BOP failures were the ram preventers and the main control systems.

Holand and Skalle (2001) conducted a study looking at BOP performance and deepwater kicks. This study ties back to the Holand (1999) study that reported 117 BOP failures for 83 wells drilled in the years 1997 and 1998. There were 48 pressure kicks reported during the drilling of the 83 wells. There are various techniques used to suppress and equalize pressure kicks (kick-killing operations), and Holand and Skalle concluded that kick killing operations were a likely contributor to four of the BOP failures.

West Engineering Services (2002) conducted a study on the shearing capability of the BOP shear ram based on results of fully actuated BOP's from operator-provided effectiveness tests. Data was provided from seven rigs that conducted tests without hydrostatic pressure and from six rigs that tested with hydrostatic pressure. This study looked at both operational and nonoperational conditions. Five of seven tests passed (71%) the test without the hydrostatic pressure, but only three of six passed (50%) the test that accounted for increased hydrostatic pressure. The study acknowledged that different grades of casing were not tested.

When shear tests are conducted, operational parameters, such as the increased hydrostatic pressure at deepwater depths or the complete range of casing steel or pipe thicknesses, are rarely factored in. If a BOP is actuated at a casing joint, the casing is greatly over thickened at that point. Barstow et al. (2010) reported that pipe joints can make up almost 10 percent of the drill pipe's length. Should the shear ram be opposite the threading or upset (the thickening of the pipe to compensate for the threads that may be externally or internally expressed on the pipe wall) of a pipe joint, the ram would be trying to shear a pipe overthickened perhaps beyond its design specifications. However, if two rams are part of the BOP configuration, at least one ram is likely to be opposite pipe without a joint at all times. The BOP's account for such a condition by using both pipe and annular rams at different levels in the BOP stack; the assumption being that redundant system would be failsafe. Double ram configurations, however, were not required by this Agency or by current post-DWH event BOEMRE regulations (**Chapter 1.3.1**).

West Engineering Services (2004) conducted a study to evaluate if a rig's BOP equipment could shear pipe to be used in a given drilling program at the most demanding condition to be expected. The study was prompted by the advances in drilling pipe metallurgy combined with larger and heavier pipe sizes used in deepwater drilling programs. West Engineering Services' (2004, p. 3-1) evaluation followed their 2002 study that referred to the 2002 results as "a grim snapshot" of industry's preparedness. West reported that the latest generation of high-ductility drilling pipe has been seen in some cases to double the shearing pressures required to sever the pipe compared with lower ductility pipe of the same weight, diameter, and grade through which only careful record keeping aboard the rig can determine which pipe is of what specification. West Engineering Services (2004) concluded that pressures that should be considered when predicting successful pipe shear often are not, such as net hydrostatic pressure at water depth (combined pressure effects of seawater, BOP hydraulic fluid, and drilling mud) and closing rams against the pressure in a wellbore kick. The following are among West Engineering Services' recommendations: (1) design BOP stack for drilling programs using the worst-case information, such as maximum anticipated drilling pipe specifications, and compensatory pressures at depth acting to require a higher shear strength to separate pipe; (2) establish a maximum length for tool joints and upsets; (3) stop designating drill pipe weight per foot in favor of actual pipe wall thickness; (4) establish an industry-wide database of shear forces/pressures in materials tests carried out by prescribed procedure with prescribed test parameters and material test specifications; and (5) encouraging industry to share data, a role for this Agency. Part of the post-DWH event, spill regulatory changes for 30 CFR 250.416(e) is that third-party verification is required for all BOP's that the blind-shear rams installed in the BOP stack are capable of shearing the drill pipe in the hole under maximum anticipated surface pressure.

West Engineering Services (2006) conducted a study to assess the acceptability and safety of using equipment, particularly BOP's and wellhead components, at pressures in excess of rated working pressure. Running equipment in excess of the maximum operating pressure is considered a poor practice and is rarely seen except for accidental or emergency use. If equipment is damaged during operation over maximum working pressure, the study implied that a downgrade would be a temporary remedy until the system is removed from service or until repaired.

Melendez et al. (2006) wrote his Master's Thesis at Texas A&M on the risk assessment of surface versus subsea BOP's on MODU's. Melendez et al. determined that the reliability of the surface BOP system compared with the subsea BOP system was nearly equal. This was the case even as the subsea BOP system used more redundant components than the surface BOP system. Melendez et al. (2006) also determined that the addition of a subsea isolation device improved the system reliability and recommended subsea isolation devices be used for deepwater operations in the GOM.

MCS Advanced Subsea Engineering (2010) conducted a risk analysis on the use of surface BOP's. MCS Advanced Subsea Engineering concluded that a surface BOP carries more potential risk to the vessel and personnel, but it may not increase the overall risk of the operation. Although the BOP is closer to the vessel and allows easy access by rig personnel, the crew exposure time during a wild well condition

is lessened because of a simpler and cleaner kill operation at the surface. Proper inspections and maintenance is critical because the BOP is the only barrier between the vessel and personnel during a catastrophic blowout condition.

Conclusions

Izon et al. (2007) indicate that approximately 10 percent of all wells drilled experienced some loss of well control incidents over the years 1992-2006, an improvement from 35 percent in the previous 15-year period. Most loss of well control events are recoverable and result in no environmental releases.

Despite a mixed assessment of BOP effectiveness over the last 12 years, this Agency has made no changes in regulation for BOP's in the face of such ambiguous results. The need for redundant well control systems was recognized and judged desirable in TA&R studies. The TA&R studies conclude that the failure rate for surface BOP's was worse than for subsea BOP's (Tetrahedron, Inc., 1996) but that both types of units approached 50 percent failure rates in effectiveness studies. No TA&R study was carried out under strictly controlled conditions that simultaneously accounted for different BOP ram types, rig mount locations, the metallurgy and thickness of casing steel, or deepwater pressure and temperature conditions.

The new post-DWH event safety requirements put in place on October 14, 2010 (*Federal Register*, 2010b), included several added regulations to improve the safety of well control systems (**Chapter 1.3.1**). These regulations include the following: (1) seafloor function testing of ROV intervention and deadman systems—30 CFR 250.516(d), 30 CFR 250.616(h), and 30 CFR 250.449(j) and (k); (2) third-party certification that the shear rams will shear drill pipe under maximum anticipated pressure—30 CFR 250.416(e); (3) registered professional engineer certification that the well design is appropriate for expected wellbore conditions—30 CFR 250.420(a); (4) use of dual mechanical barriers for the final casing string—30 CFR 250.420(b); (5) negative pressure testing of individual casing strings—30 CFR 250.423(c); and (5) retrieval and testing of BOP after a shear ram has been activated in a well control situation—30 CFR 250.451(i).

The BOEMRE released NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," effective November 8, 2010, to address the use of BOP's and well containment resources in the aftermath of the DWH event. The NTL only applies to operators using BOP's subsea or at the surface on floating facilities. It explains that lessees and operators submit a statement signed by an authorized company official with each application for a well permit, indicating that they will conduct all of their authorized activities in compliance with all applicable regulations, including the Increased Safety Measures Regulations (*Federal Register*, 2010b). The NTL also informs lessees that BOEMRE will be evaluating whether or not each operator has submitted adequate information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control. The NTL does not require that operators submit revised OSRP's that include this containment information at this time, the operator was notified of BOEMRE's intention to evaluate the adequacy of each operator's capability to comply in the operator's current OSRP; therefore, there is an incentive for voluntary compliance. The type of information that BOEMRE will review pursuant to this NTL includes, but is not limited to,

- subsea containment and capture equipment, including containment domes and capping stacks;
- subsea utility equipment, including hydraulic power, hydrate control, and dispersant injection equipment;
- riser systems;
- remotely operated vehicles;
- capture vessels;
- support vessels; and
- storage facilities.

3.2.3. Pipeline Failures

Significant sources of damages to OCS pipeline infrastructure are mass sediment movements and mudslides that can exhume or push the pipelines into another location, impacts from anchor drops or boat collisions, and accidental excavation or breaching because the exact whereabouts for a pipeline is uncertain.

The uncertain location of pipelines is an ongoing safety and environmental hazard. On October 23, 1996, in Tiger Pass, a channel through the Mississippi River Delta into the Gulf of Mexico near Venice, Louisiana, the crew of the Bean Horizon Corporation dredge *Dave Blackburn* dropped a stern spud (a large steel shaft that is dropped into the river bottom to serve as an anchor and a pivot during dredging operations) into the bottom of the channel in preparation for continued dredging operations. The spud struck and ruptured a 12-in diameter, submerged natural gas steel pipeline owned by Tennessee Gas Pipeline Company. The pressurized natural gas (about 930 psig) released from the pipeline enveloped the stern of the dredge and an accompanying tug, the *G.C. Linsmier*. Within seconds of reaching the surface, the natural gas ignited. The resulting fire destroyed the dredge and the tug. Twenty-eight crew members from the dredge vessel and tug boat abandoned ship or boarded nearby vessels (USDOT, National Transportation Safety Board, 1998). A description of the incident in a National Transportation and Safety Board safety recommendation (USDOT, National Transportation Safety Board, 1998) indicates that lack of awareness of the precise location of the pipeline was a major contributing factor to this accident.

On December 5, 2003, this Agency received an incident report that a cutterhead dredge barge ruptured a 20-in diameter condensate pipeline in Eugene Island Block 39. Dredging operations by COE were taking place in Atchafalaya Channel. No injuries were reported, but a small condensate spill and subsequent fire damaged the dredge barge. The incident was apparently caused by inaccurate knowledge of the pipeline's location. The global positioning system beacon was located on the barge tug rather than on the bow of the dredge barge where the suction cutterhead operated. Therefore, the true position of the pipeline relative to the suction cutterhead was in error by at least the length of the dredge barge (about 400 ft; 121 m). Lack of awareness of the precise location of the pipeline was the major contributing factor to this accident as well.

Following the 2004, 2005, and 2008 hurricane seasons, this Agency commissioned studies to examine the failure mechanisms of offshore pipelines (Atkins et al., 2007; Energo Engineering 2010; Atkins et al., 2006). **Table 3-9** shows pipelines damaged after the 2004-2008 hurricanes passing through the CPA and WPA. Much of the reported damage is riser or platform-associated damage, which typically occurs when a platform is toppled or otherwise damaged.

Table 3-10 shows the hurricane-associated spills from pipelines >50 bbl. The largest spills are typically due to pipeline movements, mudslides, anchor drops, and collisions of one type or another. Most pipeline damage occurs in shallow (<200 ft; 61 m) water because of the potential for increasing impacts of the storm on the seabed in shallow water, the relative density of pipelines, or the age and design standards of the pipeline or the platforms to which the pipelines are connected.

The future impact of hurricanes on damage to pipelines is uncertain. As oil production shifts from shallow to deeper water, there may be a consolidation of pipeline utilization that increases the risk of a large spill, but might allow a focus on the safety of a smaller number of critical pipelines.

An OCS-related spill ≥1,000 bbl would likely be from a pipeline accident for OCS coastal spills ≥1,000 bbl; where a spill size of 4,200 bbl is assumed. An OCS-related spill in coastal waters of ≥1,000 bbl and related to the proposed activity will occur less than once per year; about once every 6 years.

3.2.4. Vessel Collisions

Chapter 4.3.3 of the Multisale EIS and Chapter 3.2.2 of the 2009-2012 Supplemental EIS describes the impacting factors arising from vessel collisions in the GOM resulting from a proposed action. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and the 2009-2012 Supplemental EIS.

This Agency revised operator incident reporting requirements in a final rule effective July 17, 2006 (*Federal Register*, 2006b). The new incident reporting rule more clearly defines what incidents must be reported, broadens the scope to include incidents that have the potential to be serious, and requires the reporting of standard information for both oral and written reports. As part of the incident reporting rule,

this Agency's regulations at 30 CFR 250.188(a)(6) requires an operator to report all collisions that result in property or equipment damage greater than $25,000. "Collision" is defined as

- the act of a moving vessel (including an aircraft) striking another vessel, or striking a stationary vessel or object (e.g., a boat striking a drilling rig or platform); and
- all collisions that result in property or equipment damage greater than $25,000 must be reported.

This Agency's data show that, from 1996 to 2009, there were 226 OCS-related collisions. Most collision mishaps are the result of service vessels colliding with platforms or vessel collisions with pipeline risers. Approximately 10 percent of vessel collisions with platforms in the OCS caused diesel spills. Fires resulted from hydrocarbon releases in several of the collision incidents. To date, the largest diesel spill associated with a collision occurred in 1979 when an anchor-handling boat collided with a drilling platform in the Main Pass leasing area, spilling 1,500 bbl. Diesel fuel is the product most frequently spilled while oil, natural gas, corrosion inhibitor, hydraulic fluid, and lube oil have also been released as the result of a vessel collision. Human error accounts for approximately half of all reported vessel collisions from 2006 to 2009.

Safety fairways, traffic separation schemes, and anchorages are the most effective means of preventing vessel collisions with OCS structures. In addition, OCS-related vessels could collide with marine mammals, turtles, and other marine animals during transit. To limit or prevent such collisions, NOAA Fisheries provides all boat operators with "Whale-watching Guidelines," which is derived from the Marine Mammal Protection Act. These guidelines suggest safe navigational practices based on speed and distance limitations when encountering marine mammals. The frequency of vessel collisions with marine mammals, turtles, or other marine animals may vary as a function of spatial and temporal distribution patterns of the living resources, the pathways of maritime traffic (coastal traffic is more predictable than offshore traffic), and as a function of vessel speed, the number of vessel trips, and the navigational visibility.

3.2.5. Chemical and Drilling-Fluid Spills

Chapter 4.3.4 of the Multisale EIS and Chapter 3.2.4 of the 2009-2012 Supplemental EIS describe the impacting factors arising from chemical and drilling fluid spills in the GOM resulting from a proposed action. The discussion in this Supplemental EIS tiers from the discussion in the Multisale EIS and the 2009-2012 Supplemental EIS.

The USCG's size categories for coastal and offshore waters and are based solely on spill volume.

Minor	Medium	Major
<238 bbl (<10,000 gal)	238-2,380 bbl (10,00-99,999 gal)	≥2,381 bbl (100,000 gal)

1 bbl = 42 U.S. gallons.

Chemical Spills

Chemicals are stored and used to condition drill muds and during production and in well completions, stimulation, and workover procedures. The relative quantity of their use is reflected in the largest volumes spilled. Completion fluids are the largest quantity used and are largest releases. Between 5 and 15 chemical spills are anticipated each year, with the majority being <50 bbl in size. The most common chemicals spilled are methanol, ethylene glycol, and zinc bromide. Additional production chemicals are needed in deepwater operations where gas hydrates tend to form. Spill volumes are anticipated to remain about the same, but spill frequency can be expected to improve because of advances in subsea processing.

Spills of chemicals were within the range considered normal in 2006 and 2007. Hurricanes Gustav and Ike in 2008 caused an increase in the number of chemical spills. In 2008, there were 32 chemical spills; 22 of those spills occurred because of Hurricane Ike on September 13, 2008. The largest spill was a 713-bbl spill of calcium chloride brine (USDOI, BOEMRE, 2010f).

Synthetic-based Fluid Spills

Synthetic-based fluids (SBF's) have been used since the mid 1990's. In deepwater drilling, synthetic-based muds (SBM's) can be preferred over petroleum oil-based muds (OBM's) because of the SBM's superior performance properties. The synthetic oils used in SBM's are relatively nontoxic to the marine environment and have the potential to biodegrade (USEPA, 2000a). Three SBF spills of ≥1,000 bbl occurred between 2001 and 2004. Between 5 and 20 SBF releases are anticipated each year, with the majority being <50 bbl in size. The volume of the synthetic portion of the drill fluid rather than the total volume of the drill fluid is now used to describe spill size. Accidental riser disconnects could result in the release of large quantities of drilling fluids and are of particular concern when SBF's are in use. The study report, *Environmental Impacts of Synthetic-Based Drilling Fluids* (Neff et al., 2000), described in the 2009-2012 Supplemental EIS, was initiated, but suffered a major equipment malfunction. Because the frequency of these spills has been decreasing, additional funding was not applied to continue this study.

In 2007, a SBF spill of 1,061 bbl occurred in Green Canyon Block 726. A crack in a joint on the riser was the cause of the spill (USDOI, BOEMRE, 2010f). In 2008, an SBF spill of 1,718 bbl occurred in Mississippi Canyon Block 941 because of a valve not closing properly (USDOI, BOEMRE, 2010g).

3.3. CUMULATIVE ACTIVITIES SCENARIO

The cumulative impact of a proposed action under 40 CFR 1508.7 is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertake such acts." A cumulative impacts analysis considers the resources and impact-producing factors that are part of the proposed action and OCS Program; however, it also requires (1) identification of other activities affecting the resources, ecosystems, and human environment other than the proposed actions, (2) establishment of the geographic scope for the analysis, and (3) establishment of the timeframe for the analysis.

The activities, or factors, producing impacts that are part of the CPA proposed action and that are also part of the cumulative activities scenario are described in **Chapters 3.1 and 3.2**.

Some affected resources susceptible to impacts from the proposed action described in **Chapters 4.1** also represent activities that are part of this cumulative scenario. Some of these resources are commercial fishing, recreational fishing, recreational resources, and human resources and land use.

Activities that are part of the cumulative activities scenario, but that are not part of the proposed action, include both human-induced and natural phenomena. Some of these activities are as follows:

- State Oil and Gas Activity
  - Texas
  - Louisiana
  - State pipeline infrastructure
- Other Major Factors Influencing Offshore Environments
  - dredge material disposal
  - OCS sand borrowing
  - marine transportation
  - military activities
  - artificial reefs and rigs-to-reefs development
  - offshore liquefied natural gas projects and deepwater ports
  - development of gas hydrates
  - renewable energy and alternative use
- Other Major Factors Influencing Coastal Environments
  - sea-level rise and subsidence
  - formation extraction and subsidence

- Mississippi River hydromodification
- maintenance dredging and navigation channels
- coastal restoration programs
- Coastal Impact Assistance Program
- Gulf Coast Ecosystem Restoration Task Force

- Natural Events or Processes

  - hurricanes
  - currents as transport agents

The timeframe for the analysis first requires definition of a point from which measurements begin (baseline) and a point to which the future effects will be analyzed. The baseline for impact-producing factors for this cumulative analysis is 2010 and the 40 years leading up to it, and the future limit is the next 40 years. The 40-year time period is selected because it is the approximate longest life span of activities conducted on an individual lease. Therefore, the next 40 years is the period of time during which the activities and impacting factors that follow as a consequence of proposed CPA Lease Sale 216/222 would be influencing the environment. This analysis of cumulative effects is activity based; i.e., it focuses on the aggregate effects of the past activities that have taken place within the geographic area of the CPA without itemizing the historical details of each individual past action.

The geographic scope for the analysis ultimately lies within the area where impacts can be identified, but as a general concept are defined as the CPA out to the EEZ and landward to the border of each State's coastal zone, but will vary depending on the resource. The proposed action takes place within an area of the Gulf of Mexico where current competition for OCS space is moderately intense. Competition for OCS space in the CPA is not expected to become any more intense during the next 40 years of the cumulative activities scenario, and possibly it may become slightly less intense as oil and gas production ramps down as a result of reservoir depletion.

Space-Use Conflict Intensity

Of the activities included in the cumulative activities scenario, most of them involve temporary and exclusive use of relatively small areas of the OCS over their lifetimes. Lifetimes for these activities can be days or decades, but few of them permanently or temporarily compete directly for large areas of OCS on a semi-continuous basis. Exceptions include (1) commercial fishing, (2) military uses, and (3) marine transportation activities. All of these activities spatially coexist with OCS Program activities but differ in their potential for space-use conflict by their degree of permanence or frequency.

Commercial fishing is a semi-permanent, space-use conflict for the OCS. Essentially, commercial fishing can potentially occur anywhere OCS infrastructure does not present an obstruction. Virtually all commercial trawl fishing in the GOM is performed in water depths less than 200 m (656 ft). Ninety-three to 95 percent of the 2,128-2,340 production structures projected to be installed in the CPA between the years 2007 and 2046 are project to be in water depths ≤200 m (656 ft) (Table 4-6 of the Multisale EIS). Assuming all structures are major production structures that each displace approximately 6 ha (15 ac) of OCS space without safety zones, between 12,768 and 14,040 ha (31,550 and 34,693 ac) of OCS area would be displaced over 40 years (page 4-359 of the Multisale EIS); less than 1 percent of OCS area would be converted to temporary, but dedicated, OCS use and would not be available to trawl fishing.

Military activities are temporary space-use conflicts for the OCS. The CPA includes all or part of the following Eglin Water Test Areas: EWTA-1, EWTA-3, and EWTA-5; and all or part of the following military warning areas: W-59, W-92, W-156, and W-453. The proposed Military Areas Stipulation would reduce potential impacts, particularly in regards to safety, but military and OCS activities essentially coexist except under prearranged circumstances. The reduction in potential impacts resulting from this stipulation makes multiple-use conflicts most unlikely, but without it some potential conflict with respect to safety issues is likely. The best indicator of the overall effectiveness of the stipulation may be that there has never been an accident involving a conflict between military operations and oil and gas activities in the GOM.

Marine transportation is a transitory but persistent space-use conflict over the OCS. Commercial vessels can range across the entire GOM, but higher traffic areas are generally self-restricted to transit

corridors. The Gulf Intracoastal Waterway is a designated transit corridor with speed controls where it crosses open navigable GOM waters. The USCG has not yet determined a navigational safety zone during offloading operations for FPSO facilities. Other deepwater facilities may require up to a 500-m (1,640-ft) radius safety zone or 78 ha (193 ac) of space (USCG regulations, 33 CFR Chapter 1, Part 147.15). Otherwise the USCG or BOEMRE have no officially designated safety zones requiring activity set-backs from OCS facilities, although 500 m (1,640 ft) is a generally recognized safety buffer set-back from floating structures.

3.3.1. OCS Program

Chapter 4.1 of the Multisale EIS and Chapter 3.1 and 3.2 of the 2009-2012 Supplemental EIS describe the scenario from a proposed action and future OCS lease sales (OCS Program). **Chapters 3.1 and 3.2** of this Supplemental EIS describe the impacting factors and scenario for routine and accidental events, respectively, for the proposed action in this Supplemental EIS and future OCS lease sales (OCS Program).

The OCS Program scenario includes all activities that are projected to occur from past, proposed, and future lease sales during the 40-year activity period. Projected reserve/resource production for the OCS Program is from 28.562 to 32.570 BBO and from 142.366 to 162.722 Tcf of gas. Tables 4-4, 4-5, and 4-6 of the Multisale EIS present projections of the major activities and impact-producing factors related to future Gulfwide OCS Program activities. Projected new coastal infrastructure as a result of the OCS Program is shown in Table 4-9 of the Multisale EIS.

For this Supplemental EIS, the BOEMRE, Gulf of Mexico OCS Region, Resource and Evaluation Office's Modeling and Forecasting Team has reevaluated the exploration and development activity scenario for the OCS Program that was presented in the Multisale EIS and 2009-2012 Supplemental EIS. For purposes of the cumulative activities scenario for this Supplemental EIS, the judgment was made that the scenario published in the Multisale EIS and the 2009-2012 Supplemental EIS remain valid.

The level of OCS activity is connected to oil prices, resource potential, cost of development, and rig availability rather than just, or even primarily to, the amount of acreage leased. In addition to these historically recurrent factors, the effect of new regulations for OCS activity enacted after the DWH event (**Chapter 1.3.1**) have been taken into account for estimates of future activity. The impacts of activities associated with the OCS Program on biological, physical, and socioeconomic resources are analyzed in the cumulative impacts analysis sections of **Chapter 4.1**.

3.3.2. State Oil and Gas Activity

Chapter 4.1.3.1 of the Multisale EIS and Chapter 3.3.2 of the 2009-2012 Supplemental EIS discuss the activities involving State oil and gas exploration and development programs. All of the five Gulf Coast States have had some historical oil and gas exploration activity, and with the exception of Florida and Mississippi, all currently produce oil and gas in State waters. The coastal infrastructure that supports the OCS Program also supports State oil and gas activities.

State oil and gas infrastructure consists of the wells that extract hydrocarbon resources, facilities that produce and treat the raw product, pipelines that transport the product to refineries and gas plants for further processing, and additional pipelines that transport finished product to points of storage and final consumption. The type and size of infrastructure that supports production depends upon the size, type, and location of the producing field, the time of development, and the life cycle stage of operations.

Louisiana

Louisiana has been the second most important oil- and gas-producing state after Alaska. Oil production in Louisiana began in 1902, with the first oil production in the coastal zone in 1926. The State of Louisiana issued its first offshore oil and gas lease in 1936, and in 1937 the Pure Oil Company discovered the first Louisiana oil field 1.2 mi (1.9 km) offshore of Cameron Parish using a platform built on timber pilings in water 15 ft (4.6 m) deep. Most oil is produced in southern Louisiana and most gas is produced in northern Louisiana.

The nine contiguous parishes of the coastal zone produced more than 50 percent of the State's oil during the 1950's. Oil production peaked at 513 million bbl in 1970 and gas production peaked at

7.8 MMcf in 1969 (Ko and Day, 2004a, p. 398). For the nine contiguous coastal zone parishes in 2009, the Louisiana Dept. of Natural Resources' SONRIS lite database (Louisiana Dept. of Natural Resources, 2010) showed a total of 4,266 producing wells, 43 million bbl of oil production, and 0.43 MMcf of gas production (**Table 3-11**).

Louisiana's leasing procedure is carried out by the Petroleum Lands Division of the Office of Mineral Resources and proceeds along the following procedural steps (McKeithen, 2007): (1) industry nominates acreage for leasing every month (By law, nominated tracts cannot exceed 5,000 ac [2,023 ha], but by Mineral Board policy, the size limit of a nominated tract is further limited to only 2,500 ac [1,012 ha]); (2) the nominated tracts are then advertised in official State and parish journals; (3) competitive, sealed bidding then takes place on bonus, royalty, and rental to be received by the State (The sealed bids are opened and read into the record at a public meeting of the Louisiana Mineral Board at the time and place advertised.); and (4) if it determines that the bids are sufficient, the Louisiana Mineral Board awards the leases to the highest bidder after evaluating data provided from the staff geologists from the Geology and Engineering Division of the Office of Mineral Resources. The term of the lease is limited to 3 years for inland tracts and 5 years for offshore tracts.

The most recent oil and gas lease sale occurred on April 14, 2010. Sixty-three (63) parcels containing 19,386 ac (7,845 ha) of State lands were offered for oil and gas leasing by the Office of Mineral Resources on behalf of the State Mineral Board for Louisiana (Digital Petrodata, 2010). The number of acres offshore was unspecified. The BOEMRE expects that Louisiana will conduct regular oil and gas lease sales during the 40-year cumulative activities scenario for OCS activity, although their regularity could differ from current practices.

Mississippi

Mississippi has only an onshore oil and gas leasing program and does not issue leases for offshore activity in State waters. The BOEMRE does not expect Mississippi to institute a lease sale program in the near future, although there is at least a possibility for a change in policy with respect to leasing in State waters during the 40-year cumulative activities scenario for OCS activity following the CPA proposed action.

Alabama

The first oil test in offshore Alabama was made in Mobile Bay in 1951. The first discovery in State waters offshore Alabama was made in 1979. By 2005, a total of 80 wells were drilled in State waters. Production, mostly gas, in Alabama waters provided 154 MMcf per year, which is half the State's production (Wikipedia, 2010). Since 1980, the number of producing wells increased from 1,000 to nearly 6,000 in 2005. Over $2.4 billion worth of oil and gas are produced annually in Alabama. In 2008, there were 384 fields in Alabama with 6,710 producing wells.

Alabama has no established schedule of lease sales. The limited number of tracts in State waters has resulted in the State not holding regularly scheduled lease sales. The last lease sale was held in 1997. The BOEMRE does not expect Alabama to institute a lease sale program in the near future, although there is at least a possibility of a lease sale in State waters during the 40-year cumulative activities scenario for OCS activity following the CPA proposed action.

Florida

Gulf Oil drilled the first offshore exploration wells in Florida in 1947; these wells were in Florida Bay south of Cape Sable in Monroe County. In 1956, Humble Oil drilled an exploration well in the State waters of Pensacola Bay in Santa Rosa County. All wells drilled in State waters were dry holes. Florida banned drilling in State waters in 1992. In 2005, Florida's Governor Jeb Bush and the Florida Cabinet signed a historic settlement agreement to buy out any existing leases in State waters and to eliminate the potential for oil drilling there. Between 1987 and 1995, Chevron made commercial gas discoveries on the Destin Dome on the OCS, 25 mi (40 km) south of the western end of the Florida Panhandle in Federal OCS waters. The discovery extended eastward the highly productive Jurassic Norphlet trend from Mobile Bay. The State of Florida objected to plans to produce the discovery, however, and in May 2002,

the U.S. Government agreed to buy back seven leases from Chevron, Conoco, and Murphy Oil for $115 million and to hold in abeyance any further development of the Destin Dome discovery until 2012.

In April 2009, three committees of the Florida House of Representatives approved a bill that would allow offshore drilling in State waters >3 mi (4.8 km) from the eastern Gulf shore. The bill passed the Florida House in April 2009 but died soon after in the Florida Senate.

The BOEMRE does not expect Florida to institute a lease sale program in the near future, although there is at least a possibility of a change in policy that could lead to leasing on the OCS or in State waters during the 40-year cumulative activities scenario for OCS activity following the CPA proposed action.

Pipeline Infrastructure

The existing pipeline network in the Gulf Coast States is the most extensive in the world and has unused capacity (USDOI, MMS, 2007b, p. 4-63). The network carries oil and gas onshore and inland to refineries and terminals, and a network of pipelines distribute finished products such as diesel fuel or gasoline to and between refineries and processing facilities onshore (Peele et al., 2002, Figure 4.1). Expansion of this network is projected to be primarily small-diameter pipelines to increase the interconnectivity of the existing network and a few major interstate pipeline expansions. Any new larger-diameter pipelines would likely be constructed to support onshore and offshore LNG terminals. However, as discussed in **Chapter 3.3.3**, there is spare capacity in the existing pipeline infrastructure to move regasified natural gas to market, and deepwater ports can serve onshore facilities including intrastate as well as interstate pipelines.

There are currently 106 OCS-related (pipelines that have at one time or another carried hydrocarbon product from the OCS) pipeline landfalls in the LCA (Table 3-38 of the Multisale EIS). Included in that figure is a subset of 47 pipeline systems under DOT jurisdiction; these systems originate in Federal waters and terminate onshore or in Louisiana State waters (Gobert, 2010) (**Figure 3-2**).

Pipelines that are constructed to serve the OCS and that are located in the LCA between now and 2046 could result in direct impacts by displacing wetlands, but new construction would likely be along existing pipeline corridors and emplaced under wetlands using amphibious vehicles and required route backfilling. Pipelines International (2010) explained the procedures recently used by builders of a 30-in-diameter onshore pipeline in near Hackberry, Louisiana, and a 24-in-diameter pipeline near Lottie, Louisiana. The following 10 steps for modern pipeline construction in wetlands used for the 30-in-diameter pipeline were explained (Pipelines International, 2010):

(1) move in equipment and personnel to establish and prepare right-of-way for continuous access;

(2) identify and mark sensitive areas;

(3) determine logistics for pipe, material, and personnel movement;

(4) backhoe equipment trenches a ditch with sufficient depth and width to accommodate pipe installation;

(5) crews perform welding, coating, and quality control functions and then install sufficient floats for buoyancy purposes;

(6) equipment then guides different sections into final position before removing floats;

(7) equipment and personnel are dispatched to remote locations to weld all sections in advance of backfilling;

(8) after substantial backfill and all welding is completed, the entire line is subjected to hydrostatic testing to confirm suitability for intended use;

(9) after hydrotest, tie-ins are completed; and

(10) final cleanup and restoration, and move out equipment and personnel construction.

As discussed in Chapter 4.1.3.2.6 of the Multisale EIS, the existing pipeline network in the Gulf Coast States is developed and extensive, with spare capacity in the existing pipeline infrastructure. Any

new larger diameter pipelines would likely be constructed to support onshore and offshore LNG terminals. The spare pipeline capacity is able to move the regasified natural gas to market, and deepwater ports can serve onshore facilities, including intrastate as well as interstate pipelines. Any expansions are projected to be primarily small diameter pipelines to increase the interconnectivity of the existing network and a few major interstate pipeline expansions.

CPA Proposed Action Scenario: As reported is **Chapter 3.1.1.4.1** for the CPA proposed action, 0-1 new landfalls are projected. Any pipeline built as the result of the proposed action is most likely to be a subsea tie-in located in State waters; therefore, landloss projected to result from pipeline installations is not anticipated. New pipelines that landfall now call for mitigations that result in “no net loss” of wetland, no new direct wetland losses are projected over the cumulative activities scenario from OCS-related pipeline construction.

OCS Program Scenario: Pipeline landfalls in the GOM peaked in the 1970’s (**Figure 3-2**). The total length of OCS-related pipeline built would be partially based on future OCS leasing activity. For the OCS Program between the years 2007 and 2046, Table 4-5 of the Multisale EIS reported that a range of 2,340 to 9,580 km (1,454 to 5,983 mi) of pipeline are projected to be built in the CPA in water depths of ≤60 ft (18 m).

3.3.3. Other Major Factors Influencing Offshore Environments

Natural and man-caused influencing factors occur in the offshore areas of Gulf States while OCS activity takes place at the same time. Some of these factors are (1) dredged material disposal, (2) OCS sand borrowing, (3) marine transportation, (4) military activities, (5) artificial reefs and rigs-to-reefs development, (6) offshore LNG projects, (7) characterization of gas hydrates, and (8) renewable energy and alternative use.

Dredged Material Disposal

Chapter 4.1.3.2.1 of the Multisale EIS discusses offshore disposal of dredged material. Dredged material is described at 33 CFR 324 as any material excavated or dredged from navigable waters of the United States. Materials from maintenance dredging are primarily disposed of offshore on existing dredged-material disposal banks and in ocean dredged-material disposal sites (ODMDS), which are regulated by USEPA. Additional dredged-material disposal areas for maintenance or new-project dredging are developed as needed and must be evaluated and permitted by COE and relevant State agencies prior to construction.

Dredged materials disposed offshore are not available for potential beneficial uses to restore and create habitat, beach nourishment projects, and industrial and commercial development; a use called the beneficial use of dredge materials program by COE (**Chapter 3.3.4**). Virtually all ocean dumping that occurs today is maintenance dredging of sediments from the bottom of channels and waterbodies in order to maintain adequate channel depth for navigation and berthing. There are four small ODMDS’s offshore Louisiana and Mississippi along open-water stretches of the main GIWW between Louisiana and Mississippi: in Louisiana ODMDS 66 (1,593 ac; 645 ha); and in Mississippi ODMDS 65A (1,962 ac; 794 ha), 65B (815 ac; 330 ha), and 65C (176 ac; 71 ha) (U.S. Dept of the Army, COE, 2008, Table 1). Dredged materials from GIWW are sidecast at these ODMDS locations. The ODMDS’s designated by USEPA for general-purpose, continuing use in the cumulative activities area include those shown in **Table 3-12**. Maps show the locations for the ODMDS’s in Louisiana (USEPA and U.S. Dept. of the Army, COE, 2003, Appendix D).

The COE’s Ocean Disposal Database reports the amount of dredged material disposed in ODMDS’s by district (U.S. Dept. of the Army, COE, 2011a).

Current figures vary for how much of the average annual 70 million yd^3 (53,518,840 m^3) that is dredged by the New Orleans District is available for the beneficial use of dredge materials program; from 15 million yd^3 (11,468,320 m^3) (U.S. Dept. of the Army, COE, 2009a, p. 26) to 30 million yd^3 (22,936,650 m^3) (Green, 2006, p. 6), or between 21 and 43 percent of the total. The remaining 79 to 57 percent of the total material dredged yearly by COE New Orleans District is disposed of in ODMDS’s or is stored in temporary staging areas located inland (e.g., the Pass a Loutre Hopper Dredge Disposal Site at the head of the Mississippi River’s main “birdfoot” distributary channel system).

Between 2000 and 2009, the New Orleans District disposed of the following quantities of dredged materials in ODMDS's (U.S. Dept. of the Army, COE, 2011a).

New Orleans District
Quantities of Dredged Materials Disposed of in ODMDS, 2000-2009

Year	Amount Disposed of in ODMDS	
	yd^3	m^3
2000	16,377,800	12,522,466
2001	23,272,300	17,794,001
2002	57,643,200	44,073,991
2003	22,546,200	17,238,825
2004	21,156,300	16,176,107
2005	21,403,200	16,364,887
2006	13,493,400	10,317,054
2007	17,550,700	13,419,265
2008	16,800,900	12,845,968
2009	16,295,000	12,459,157
Average per year	22,653,900	17,321,172

Cumulative Activities Scenario: The BOEMRE anticipates that over the next 40 years the amount of dredged material disposed at ODMDS's will fluctuate generally within the trends established by the New Orleans District. The New Orleans District has averaged about 22 million yd^3 of material dredged per year disposed at ODMDS's over the last 10 years. Quantities may decrease slightly as more beneficial uses of dredged material onshore are identified. The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention), to which the U.S. is a signatory, requires annual reporting of are amount of materials disposed at sea. The COE prepares the dredged material disposed portion of the report to the International Maritime Organization, the yearly reports for which are posted on COE's Ocean Disposal Database (U.S. Dept. of the Army, COE, 2011b).

OCS Sand Borrowing

Chapter 4.1.3.2.2 of the Multisale EIS discusses in detail this Agency's Marine Minerals Program, which provides policy direction for the development of marine mineral resources on the OCS. If OCS sand is desired for coastal restoration or beach nourishment, BOEMRE uses the following two types of lease conveyances: a noncompetitive negotiated agreement that can only be used for obtaining sand and gavel for public works projects funded in part or whole by a Federal, State, or local government agency; and a competitive lease sale in which any qualified person may submit a bid. The BOEMRE has issued 29 noncompetitive negotiated agreements but has never had a competitive lease sale for OCS sand and gravel resources. The OCS Program continues to focus on identifying sand resources for coastal restoration, investigating the environmental implications of using those resources, and processing noncompetitive use requests.

This Agency has participated in the multi-agency Louisiana Sand Management Working Group since 2003 to identify, prioritize, and define a pathway for accessing sand resources in the near-offshore OCS of Louisiana, an area where competitive space use mainly involves OCS oil and gas infrastructure such as wells, platforms, and pipelines. **Table 3-13** shows the projected OCS sand uses for coastal restoration projects over approximately the next 5 years. Approximately 76 million yd^3 are expected to be needed for coastal restoration projects as reported by the Louisiana Office of Coastal Protection and Restoration. To visualize such a dimension, it is equivalent to a volume of sand that could fit on a National Football League field (300 x 160 ft) to a height of 2.71 mi (4.3 km) high.

This Agency received earmarked funds in 2005 to conduct offshore sand studies to investigate available sources of OCS sand for restoring coastal areas in Louisiana, Texas, Alabama, and Mississippi that were damaged by Hurricanes Katrina and Rita. Sand sources identified through this Agency's cooperative effort with Louisiana will likely serve as the major source of material for the restoration of the barrier islands planned as part of the LCA ecosystem restoration study (U.S. Dept. of the Army, COE,

2004a). The Louisiana Office of Coastal Protection and Restoration and Louisiana State University have undertaken joint efforts, funded in part through BOEMRE, to identify potential sand resources in the Trinity and Tiger Shoal complex, located in the Vermilion and South Marsh Island leasing areas, and to examine the long-term effects of dredging sand on Ship Shoal, a large potential borrow area about 15 mi (24 km) offshore Isle Dernieres, south central Louisiana. Meanwhile, the General Land Office in Texas is collecting new geologic and geophysical data to identify and characterize potential resources in buried Pleistocene Sabine and Colorado River paleochannels, located offshore Jefferson and Brazoria Counties.

Since the dredging of OCS sand and the associated activities of oceangoing dredge vessels could present some use conflicts on blocks also leased for oil and/gas extraction, this Agency initiated a regional offshore sand management program in Louisiana in 2003, which over the course of 7 years and several meetings has developed options and recommendations for an orderly process to manage the competing use of OCS sand resources in areas of existing OCS infrastructure. With input from the Sand Management Working Group, BOEMRE has developed guidelines for sand resource allocations, maintaining a master schedule of potential sand dredging projects, developing procedures for accessing sand under emergency conditions, and establishing environmental requirements for the use of offshore borrow areas.

The following five leases for OCS sand have been issued in the CPA: (1) Holly Beach, Cameron Parish, Louisiana; (2) the South Pelto test area, Terrebonne Parish, Louisiana; (3) Pelican Island shoreline restoration, Plaquemines Parish, Louisiana; (4) Raccoon Island marsh creation, Terrebonne Parish, Louisiana, and (5) St. Bernard Shoals, St. Bernard and Plaquemines Parish, Louisiana.

In May 2002, this Agency completed a negotiated lease with the U.S. Dept. of Agriculture's Natural Resource Conservation Service and the Louisiana Dept. of Natural Resources for the Holly Beach project (CWPPRA Project CS-31) in Cameron Parish, Louisiana. The project goals were as follows: (1) to reestablish a more historical shoreline configuration, as well as improve the effectiveness of the existing segmented breakwater system, and protect approximately 8,000 ac (3,237 ha) of low-energy intermediate and brackish marsh wetlands; and (2) to create and protect roughly 300 ac (121 ha) of beach dune and coastal chenier habitat from erosion and degradation. The project also protected a wooded chenier that serves as a sanctuary for Neotropical migratory birds. The project involved the use of approximately 1,762,583 yd^3 (1,347,600 m^3) of OCS sand from Sabine Bank and the buried Peveto paleochannel approximately 5 mi (8 km) south of Holly Beach. Construction was completed in March 2003.

In December 2002, this Agency completed a negotiated lease with the Louisiana Dept. of Natural Resources to use a hopper dredge to extract approximately 3,000 yd^3 (2,294 m^3) of sand from Ship Shoal within South Pelto Block 12 to determine the loading characteristics and "overfill factor" of the sand from the eastern end of Ship Shoal. The sand was determined to be high-quality sand for barrier island restorations. The test was completed in December 2002.

In June 2008, this Agency completed a 3-party noncompetitive negotiated agreement with NOAA and the Louisiana Dept. of Natural Resources for the Barataria Barrier Island Complex Project: Pelican Island and Pass La Mer to Chaland Pass Restoration (CWPPRA Project BA-38) in Plaquemines Parish, Louisiana. The project's objectives are as follows: (1) preventing the breaching of the barrier shoreline by increasing barrier width and height; (2) increasing back-barrier, emergent marsh area by some 220 ac (89 ha) to maintain the barrier shoreline; (3) restoration and creation of about 180 ac (73 ha) of dune, beach, and berm; and (4) creating emergent marsh suitable for tidal aquatic habitats. This project will use approximately 5,523,000 yd^3 of OCS sediment from the buried Sandy Point paleochannels (West Delta Blocks 26, 27, and 49). The project was authorized in 2002 by CWPPRA, and the lease was requested in July 2003. It is anticipated that construction will begin in 2011.

In May 2009, this Agency completed a 3-party negotiated agreement with the U.S. Dept. of Agriculture's Natural Resource Conservation Service and the Louisiana Dept. of Natural Resources for the Raccoon Island Protection/Marsh Creation Phase B project (CWPPRA Project TE-48) in Terrebonne Parish, Louisiana. Raccoon Island is the westernmost barrier island in the Isles Dernieres chain and is a project that has been separated into two construction phases. Phase A includes the construction of eight additional segmented breakwaters Gulfward of the island. Phase B involves the construction of a retention dike along the northern shore at the westernmost end of the island to create a back bay enclosure of approximately 60 ac (24 ha) to create back-barrier marsh habitat that protects and enhances an important rookery for seabirds. The project plans for the use of approximately 750,000 yd^3 (573,400 m^3)

of OCS sediment from a borrow area 4 mi (6 km) south of Raccoon Island in Ship Shoal Blocks 64 and 71. It is anticipated that construction will begin in 2011.

Part of the DWH event response by the State of Louisiana involved the construction of artificial sand berms seaward of existing barrier island shorelines to protect fragile coastal marsh and estuarine environments from the landfall of oil. The details of this project are discussed in **Appendix D**. Of the 101 mi (163 km) of berm originally contemplated in the State's berm program, 45 mi (72 km) were approved by COE and UIC, for which BP would pay $360 million. On May 14, 2010, the Louisiana Office of Coastal Protection and Restoration requested a BOEMRE lease to use OCS sand from St. Bernard Shoals for construction of the emergency sand berms, and on July 16, 2010, an emergency negotiated agreement was executed. However, no OCS sand was used during the construction of the emergency berms because (1) the use of hopper dredges in the Gulf was not allowed after excessive nonlethal and lethal turtle takes occurred during the first week of dredging in State waters and (2) the Federal On-Scene Coordinator for the DWH event notified the State that their request for concurrence for dredging activity at St Bernard Shoals was denied. The berms were completed in March 2011. A total of approximately 10,300,000 yd^3 of sand was placed to construct 20.5 mi (4 km) of berm, of which 8.8 mi (14.2 km) was constructed along the E-4 segment along the northern Chandeleur Islands in St. Bernard Parish and 11.7 mi (18.8 km) were constructed along the W-8, W-9, and W-10 segments in Plaquemines Parish. All sand used to construct the berm was mined from Hewes Point north of the Chandeleur Islands (Louisiana State waters) and from the lower Mississippi River.

The BOEMRE is currently working with Louisiana on two negotiated agreements for upcoming projects: Cameron Parish Beach Restoration and Caminada Headland Restoration. The Cameron Parish project proposes to utilize sand from Sabine Bank (West Cameron Blocks 114 and 117), and the Caminada Headland project proposes to use sand from Ship Shoal (South Pelto Blocks 12, 13, 14, 18, and 19).

Cumulative Activities Scenario: Great uncertainty exists for how much OCS sand offshore the State of Louisiana will eventually be sought for future coastal restoration projects. The CWPPRA projects that are authorized may seek to access it, but other future programs that intend to use OCS sand include the Louisiana Coastal Protection and Restoration Authority's Annual Plan and the coastal restoration and flood protection projects that are part of COE's plan (U.S. Dept. of the Army, COE, 2009c, Figures 17-1, 17-2, and 17-3).

Marine Transportation

Chapter 4.1.3.2.3 of the Multisale EIS and Chapter 3.3.3 of the 2009-2012 Supplemental EIS discuss the extensive maritime industry that exists in the northern GOM. Freight and cruise ship passenger marine transportation within the analysis area should continue to grow at a modest rate or remain relatively unchanged based on historical freight traffic statistics under current conditions. The Port of New Orleans was the sixth largest port in the United States in terms of tonnage handled in 2008. Tankers carrying mostly petrochemicals account for about 40 percent of the vessel calls. Dry-bulk vessels carrying coal, coke, grain, etc., account for another 40 percent of vessel calls. New Orleans is a popular port for cruises. The Port of New Orleans supports year-round operations at the Julia Street and Erato Street cruise terminals that, in 2009, saw 101 cruise ship departures (Chambers, 2010).

Trends for use of all Gulf Coast ports show an increase from 31.2 to 34.1 percent of total U.S. port use (USDOT, MARAD, 2009) between 2004 and 2009 (**Table 3-14**), an increase of about 3 percent over the past decade. The estimated number of vessel trips that would occur as a result of the CPA proposed action is presented in **Table 3-2**. Use by the OCS Program represents a small percentage of total marine transportation in the GOM, <1 percent of reported usage for Federal channels (**Chapter 3.1.1.4.4**).

Cumulative Activities Scenario: The BOEMRE anticipates that, over the next 40 years, the total amount of Gulf Coast port usage will be bounded by a lower limit of the approximate levels of current use and a higher limit consisting of a steady increase of approximately 3 percent each decade.

Military Activities

Chapter 4.1.3.2.4 of the Multisale EIS and Chapter 3.3.3 of the 2009-2012 Supplemental EIS discuss in detail the extensive use of the offshore GOM for military activities. Twelve military warning areas and six Eglin Water Test Areas (EWTA's) are located within the Gulf (**Figure 2-3**). The CPA includes all or

part of the following Eglin Water Test Areas: EWTA-1, EWTA-3, and EWTA-4; and all or part of the following military warning areas: W-59, W-92, W-147 W-155 and W-453. The air space over the CPA is used by the DOD for conducting various air-to-air and air-to-surface operations. These warning and water test areas are multiple-use areas where military operations and oil and gas development have coexisted without conflict for many years. Several military stipulations are planned for leases issued within identified military areas.

Cumulative Activities Scenario: The BOEMRE anticipates that, over the next 40 years, the military use areas currently designated in the CPA will remain the same and that none of them would be released for nonmilitary use. Over the cumulative activities scenario, BOEMRE expects to continue to require military coordination stipulations in these areas. The intensity of the military's use of these areas, or the type of activities conducted in them, is anticipated to fluctuate with the military mission needs.

Artificial Reefs and Rigs-to-Reefs Development

Chapter 4.1.3.2.5 and Appendix A.4 of the Multisale EIS and Chapter 3.3.3 of the 2009-2012 Supplemental EIS discuss in detail artificial reefs and rigs-to-reefs development in the GOM. Artificial reefs have been used along the coastline of the U.S. since the early 19th century. Stone (1974) documented that the use of obsolete materials to create artificial reefs has provided valuable habitat for numerous species of fish in areas devoid of natural hard bottom. Stone et al. (1979) found reefs in marine waters not only attract fish, but in some instances also enhance the production of fish. All of the five Gulf Coast States—Texas, Louisiana, Mississippi, Alabama, and Florida—have artificial reef programs and plans.

Most OCS platforms have the potential to serve as artificial reefs. Offshore oil and gas platforms began providing artificial reef substrate in the GOM with the first platform's installation in 1942. Historically, approximately 9 percent of the platforms decommissioned in the Gulf OCS have been used in the Rigs-to-Reefs Program. It is anticipated that approximately 10 percent of platforms installed as a result of the CPA proposed action would be converted to a reef after decommissioning. This factor is prompting increased public attention on the ecologic value of oil and gas structures for their reef effects. Ongoing studies aim at evaluating the ecology of offshore structures and may lead to a greater emphasis on creation of artificial reefs through the Rigs-to-Reefs Program. At present, Texas, Louisiana, and Mississippi participate in the Rigs-to-Reefs Program.

CPA Proposed Action Scenario: The number of platforms projected for the proposed action in the CPA is 32-44 (**Table 3-2)**. The number of rigs-to-reefs anticipated as a result of the CPA proposed action is approximately 10 percent of the projected removals, or 3-4 in the CPA.

OCS Program Scenario: For the OCS Program from the years 2007-2046, a total of 4,925-4,949 platforms in the CPA are projected to be removed during the 40-year cumulative activities scenario (Table 4-6 of the Multisale EIS). If approximately 10 percent of these structures are accepted into the Rigs-to-Reefs Program, there may be as many as 492-495 additional artificial reefs installed in the CPA or elsewhere.

Offshore Liquefied Natural Gas Projects and Deepwater Ports

Chapter 4.1.3.2.6 of the Multisale EIS discusses in detail offshore LNG terminals projected, approved, and existing in the GOM. One LNG terminal is presently operating on the OCS in the GOM: the Gulf Gateway Energy Bridge. Brought into service in March 2005, the Gulf Gateway Energy Bridge is located in 280 ft (85.3 m) of water in West Cameron, South Addition Block 603, approximately 116 mi (187 km) offshore the Texas-Louisiana border. The Gulf Gateway Energy Bridge is capable of delivering natural gas at a baseload rate of 500 Bcf per day. The license for the Gulf Gateway Energy Bridge operation was issued by DOT's Maritime Administration (MARAD) on May 24, 2004.

Exxon-Mobile's Golden Pass LNG terminal on the Sabine Pass waterway in Jefferson County near the Texas-Louisiana border and Port Arthur, Texas, was scheduled to open in 2009, but it was severely damaged by Hurricane Ike in September 2008. At full operation, Golden Pass will be able to deliver the equivalent of 2 Bcf per day of natural gas. Golden Pass received its first shipment of super-cooled LNG on October 28, 2010, at which time (Gonzalez, 2010) reported that it arrived in the midst of a domestic gas surplus.

"Shale gas" is a new source of onshore natural gas that is easy to reach, and it is throwing plans for LNG terminals into turmoil. Recent technological improvement in fracing tight geologic formations has opened the shale gas frontier. Shale gas is held in fine-grain formations, such as shale, that is difficult to produce without introducing artificial fractures (fracing) through which gas can flow to a wellbore and be produced. The prospect of a larger, more accessible, domestic gas supply acts to depress gas prices and affects the economics for heavily capitalized LNG installations. The Henry Hub price of natural gas between 2002 and 2007 fluctuated between $5.00 and $8.00 Mcf. The price spiked to $15.00 Mcf after the 2005 GOM hurricanes, and a speculative bubble peak high price of $13.00 Mcf was reached in July 2008. With aggressive discovery and production of shale gas and the Great Recession, the Henry Hub price of natural gas in 2009 and 2010 collapsed to fluctuate between $2.00 and $5.00 Mcf for most of this period. The LNG or deepwater port facilities below are now in some stage of the permitting process (USDOT, MARAD, 2010).

Alabama

Bienville Offshore Energy Terminal. TORP Technology LP filed an application on January 12, 2006, for an LNG facility to be located in the GOM, 63 mi (101 km) south of Mobile Point, Alabama. The proposed facility will consist of a HiLoad Unit, which is a floating structure connecting directly to the LNG carrier hull. The MARAD and USCG stopped the regulatory timeline for processing the application on August 21, 2007, after determining that additional information was needed to effectively process the application. On October 9, 2008, the applicant elected to withdraw its application in order to consider technical modifications to its proposed project. A revised application was submitted on June 30, 2009, featuring a redesigned terminal using "closed loop" ambient air technology for LNG vaporization, and a Notice of Amended Application and Notice of Intent to produce a supplemental EIS was published in the *Federal Register* on August 5, 2009. A public hearing was held in Mobile, Alabama, on December 9, 2009. On September 14, 2010, the Governor of Alabama approved the Bienville Offshore Energy Terminal application with conditions. The USCG is working with MARAD to prepare the Record of Decision.

Louisiana

Main Pass Energy Hub. Freeport McMoran filed a notice of revised application on June 22, 2006, to convert a sulphur/brine mining facility into an LNG terminal for regasification. An EIS was prepared and the Governor of Louisiana issued an approval letter on November 20, 2007. The Main Pass Energy Hub would be located 16 mi (26 km) offshore Louisiana in Main Pass Block 299. As of May 27, 2009, the Federal Energy Regulatory Commission granted a 1-year extension to Freeport McMoran to build a pipeline associated with the facility, and Freeport McMoran is in the process of seeking gas suppliers.

Development of Gas Hydrates

The DOE and cooperating agencies are in the middle of a multiyear characterization program of naturally occurring methane hydrates (gas hydrates) in the GOM. The first cruise for characterizing GOM gas hydrates took place in 2005, and the second took place in 2009. A third cruise is in the planning stages. Gas hydrates are a unique, energy-rich, and poorly understood class of chemical substances in which molecules of one material (in this case solid-state water—ice) form an open lattice that physically encloses molecules of a certain size (in this case—methane) in a cage-like structure without chemical bonding (Berecz and Balla-Achs, 1983; Henriet and Mienert, 1998; Collett, 2002). Studying gas hydrates poses unique technical challenges because they occur only in remote and hostile environments—arctic landmasses and deepwater continental shelves. Moreover, they are only stable in high-pressure and low-temperature environments, and they are difficult to extract from their natural setting for laboratory study.

The Methane Hydrate Research and Development Act of 2000 (P.L. 106-193; May 2, 2000) promoted the research, identification, assessment, exploration, and development of methane hydrate resources in the United States as the work of a joint effort between seven Federal agencies. The DOE is the coordinating agency and participants include the USGS, this Agency, BLM, the Naval Research Laboratory, NOAA,

and the National Science Foundation. The Methane Hydrate Research and Development Act of 2000 was reauthorized for 2005-2010 in Section 968 of the EPAct.

The Methane Hydrate Research and Development Act of 2000 allows DOE to enter into awards, contracts, and cooperative agreements with institutions of higher education or industrial enterprises for the purposes of (1) conducting basic and applied research to identify, explore, assess, and develop methane hydrate as a source of energy; (2) developing technologies required for efficient and environmentally sound development of methane hydrate resources; (3) undertaking research programs to provide safe means of transport and storage of methane produced from gas hydrates; (4) promoting education and training in methane hydrate resource research and resource development; (5) conducting basic and applied research to assess and mitigate the environmental impacts of hydrate degassing (including both natural degassing and degassing associated with commercial development); (6) developing technologies to reduce the risks of drilling through naturally occurring methane hydrates; and (7) drilling in support of authorized activities.

Seismic evidence for gas hydrates typically consists of a bottom simulating reflector at relatively shallow depths below mudline; shallow at least in comparison with conventional oil and gas exploration wells. The bottom simulating reflector is caused by the large acoustic impedance contrast at the base of the gas hydrate stability zone that separates sediments containing gas hydrate above with sediments containing free gas below.

In the Gulf of Mexico a Joint Industry Project (JIP) was formed to carry out an assessment of gas hydrates. Members of the 2009 JIP included ChevronTexaco (operator); this Agency; ConocoPhillips; Halliburton; Total; Schlumberger; Reliance Industries Limited; Japanese Oil, Gas, and Metals National Corporation; Korea National Oil Company; and StatoilHydro. Three legs to the total JIP were planned. For the first leg in 2005, JIP carried out a test drilling program to sample gas hydrates on the Gulf of Mexico OCS at eight locations in three blocks (Atwater Valley Blocks 13 and 14, and Keathley Canyon Block 151) in the CPA where hydrates were thought to occur. The results of the 2005 JIP were published in the DOE newsletter *Fire in the Ice* (Birchwood et al., 2008).

For the second leg in 2009, the JIP was permitted by this Agency to carry out a test drilling program to sample gas hydrates on the Gulf of Mexico OCS at multiple locations in two blocks; Green Canyon Block 955 and Walker Ridge Block 313 in the CPA and Alaminos Canyon Blocks 775, 818, and 819 in the WPA. JIP modified the WPA drilling program to include two boreholes in Alaminos Canyon Block 21 instead of the originally permitted blocks (Fire in the Ice, 2009) and deployed for Leg II in April 2009 using a dynamically-positioned drillship. The test wells were 8.5-in-diameter that penetrated shallow sediment up to 3,680 ft (1,122 m) below mudline to allow geophysical logging followed by abandonment procedures. All wells were geophysically logged while drilling with resistivity, borehole imaging, gamma ray, density, neutron porosity, and magnetic resonance logs. Unlike the 2005 JIP program in the GOM, the 2009 JIP did not retrieve pressurized cores of gas hydrate from the sampled holes. Technical reports resulting from the 2009 JIP include Boswell et al. (2009), Kou (2010), and Zhang and McConnell (2011).

This Agency released the results of a systematic geological and statistical assessment of gas hydrates resources in the GOM (USDOI, MMS, 2008b). This assessment incorporates the latest science with regard to the geological and geochemical controls on gas hydrate occurrence. It indicated that a mean volume of 607 trillion m^3 (21,444 Tcf) of methane was in-place in hydrate form. The assessment has determined that a mean of 190 trillion m^3 (6,710 Tcf) of this resource occurs as relatively high-concentration accumulations within sand reservoirs that may some day be produced. The remainder occurs within clay-dominated sediments from which methane probably would never be economically or technically recoverable.

Cumulative Activities Scenario: The BOEMRE anticipates that, over the next 40 years, JIP will complete the third leg of their characterization project for GOM gas hydrates in the cumulative impacts area. Within 40 years, it is likely that the first U.S. domestic production from hydrates may occur in Alaska, where gas obtained from onshore hydrates will either support local oil and gas field operations or be available for commercial sale if and when a gas pipeline is constructed to the lower 48 states. However, Moridis et al. (2008, p. 4) stated that it is not possible to discount the possibility that first U.S. domestic production of gas hydrates could occur in the GOM. Despite the substantially increased complexity and cost of offshore operations, there is a mature network of available pipeline capacity and easier access to markets in the GOM.

Renewable Energy and Alternative Use

Chapter 4.1.3.3.5 of the Multisale EIS and Chapter 3.3.6 of the 2009-2012 Supplemental EIS discuss the renewable (sometimes called "alternative") energy projects as they are developing in the GOM. On August 8, 2005, President George W. Bush signed into law the EPAct of 2005. Section 388 (a) of EPAct amended Section 8 of the OCSLA (43 U.S.C. 1337) to authorize DOI to grant leases, easements, or rights-of-way on the OCS for the development and support of energy resources other than oil and gas and to allow for alternate uses of existing structures on OCS lands.

A final programmatic EIS for the OCS renewable energy program was published by this Agency in October 2007 (USDOI, MMS, 2007f) and a Record of Decision was published in the *Federal Register* on January 10, 2008 (*Federal Register*, 2008). The Act authorized this Agency to develop a comprehensive program and regulations to implement the new authority. Final rules for the renewable energy program were published on April 29, 2009, as 30 CFR 285 (*Federal Registe*r, 2009b).

The two primary categories of renewable energy that have potential for development in the coastal and OCS waters of the U.S. are (1) wind turbines and (2) marine hydrokinetic systems. The first and most technologically mature renewable energy is wind energy, a popular source of clean and renewable energy that has been in use for centuries. At present, 45 offshore wind farms are in operation, all of which are located off the coast of the United Kingdom and mainland Europe in waters generally shallower than 30 m (100 ft), and 10 more offshore wind farms are currently under construction in this area (European Wind Energy Association, 2011). China and Japan also have offshore wind farms and plan to expand their offshore wind power (Feldman, 2009; Schwartz, 2010; Singh, 2010; offshoreWIND.biz, 2010).

Ocean wind energy has emerged as a promising renewable energy resource for a number of reasons: (1) the strength and consistency of winds on the ocean are roughly proportional to distance from shore, the farther from shore the stronger and more persistent; (2) offshore wind generating facilities (wind parks) can therefore be located in proximity to major load centers in the energy-constrained northeastern U.S.; (3) long-term potential for the over-the-horizon siting and undersea transmission lines counters the aesthetics and land-use concerns associated with onshore wind installations and those that can be seen easily from shore; and (4) as a fuel, wind is both cost-free and emission free (Massachusetts Technology Collaborative, 2005).

The DOE released a predecisional strategic plan for creating an offshore wind industry in the U.S. (USDOE, 2010). In this plan, DOE determined that offshore wind energy can help the Nation reduce its greenhouse gas emissions, diversify its energy supply, provide cost-competitive electricity to key coastal regions, and stimulate economic revitalization of key sectors of the economy. However, if the Nation is to realize these benefits, key barriers to the development and deployment of offshore wind technology must be overcome, including the relatively high cost of energy, technical challenges surrounding installation and grid interconnection, and the untested permitting processes governing deployment in both Federal and State waters. There are two critical objectives to realize the strategic plan's goals: (1) reduce the cost of offshore wind energy; and (2) reduce the timeline for deploying offshore wind energy (USDOE, 2010, p. 1). Since April 29, 2009, when the regulations governing renewable energy on the OCS were promulgated, no wind park developments have been proposed in OCS waters of the GOM.

The second category of offshore renewable energy is marine hydrokinetic systems, which are in a more developmental stage relative to wind turbines. The marine hydrokinetic systems consist of devices capable of capturing energy from ocean waves and currents. There has been no interest expressed in wave or current technologies in the GOM because the conditions necessary for their deployment are not suitable to the Gulf. The marine hydrokinetic current technologies are actively being considered for the east coast of Florida where the Gulf Stream provides a strong and continuous source of energy to turn underwater turbines.

The EPAct clarifies the Secretary's authority to allow the existing oil and gas structures on OCS lands to remain in place after production activities have ceased and to transfer liability and extend the life of these facilities for non-oil and gas purposes, such as research, renewable energy production, aquaculture, etc., before being removed. With approximately 1,900 bottom-founded platform structures located in OCS waters, the GOM would seem to have some potential for the reuse of these facilities. Although BOEMRE has had conversations with developers about conceptual ideas for alternative use projects, no developer has stepped forward with an application to actualize one.

Cumulative Activities Scenario: The BOEMRE anticipates that, over the next 40 years, at least one alternative use project would be brought to the Agency for action. It is also likely that at least one wind park project will be proposed offshore Louisiana in the cumulative impact area. A project could consist of a combination of integrated existing GOM infrastructure with new-built facilities. Such a projection is made because this type of project was vetted to this Agency in 2004, before the EPAct was passed to set up the framework to permit and regulate renewable energy projects on the OCS.

3.3.4. Other Major Factors Influencing Coastal Environments

Natural and man-caused factors influence the coastal areas of the Gulf States while OCS activity takes place at the same time. Some of these factors are (1) sea-level rise and subsidence; (2) Mississippi Delta hydromodifications; (3) maintenance dredging activities; (4) Coastal Impact Assistance Program activities; and (5) coastal restoration programs.

Sea-Level Rise and Subsidence

Chapter 4.1.3.3.1 of the Multisale EIS and Chapter 3.3.4 of the 2009-2012 Supplemental EIS discuss wetland submergence in the LCA. The Delta Plain and Chenier Plain of the LCA are experiencing relatively high subsidence rates as part of the Mississippi River's delta system. All coastlines of the world have been experiencing a gradual absolute rise of sea level that is based on measurements across the globe and that extends across the influence of a single sedimentary basin. There are two aspects of sea-level rise during the most geologically recent 10,000 years (Holocene Epoch): absolute rise and relative rise. Absolute sea-level rise refers to a net increase in the volume of water in the world's oceans. Relative sea-level rise refers to the appearance of sea-level rise, a circumstance where subsidence of the land is taking place at the same time that an absolute sea-level change may be occurring. Geologists tend to consider all sea-level rise as relative because the influence of one or the other is difficult to separate over geologic time frames.

An absolute sea-level rise would be caused by the following two main contributors to the volume of ocean water on the Earth's surface: (1) change in the volume of ocean water based on temperature; and (2) change in the amount of ice locked in glaciers, mountain ice caps, and the polar ice sheets. For the period 1961-2003, thermal expansion of the oceans accounts for only 23 ± 9 percent of the observed rate of sea-level rise (Intergovernmental Panel on Climate Change, 2007a, Chapter 5 and Table 5.3), the remainder is water added to the oceans by melting glaciers, ice caps, and the polar ice sheets. The contribution of thermal expansion is between 14 and 32 percent of the total absolute sea level rise over this 42-year period. The remainder, approximately 75 percent, of sea-level rise is attributed to melt water.

Measurement of sea-level rise over the last century is based on tidal gauges and, more recently, satellite observations, that are not model-dependent. Projections for future sea-level rise are dependent on temperature. As determined by analysis of air bubbles trapped in Antarctic ice cores, today's atmospheric concentration of CO_2 is the highest it has ever been over the last 800,000 years (Karl et al., 2009, p. 13). Although the measured data for atmospheric CO_2 concentration or temperatures measurements since the Industrial Revolution are generally not in dispute, proxy data for climates of the geologic past are a source of debate and the models constructed to make projections for how climate may change remain controversial. Climate models are very sophisticated, but they may not account for all variables that are important or may not assign to modeled variables the weight of their true influence.

The Intergovernmental Panel on Climate Change reported that, since 1961, global average sea level (mean sea level) has risen at an average rate of 1.8 millimeter/year (mm/yr) (0.07 in/yr) and, since 1993, at 3.1 mm/yr (0.12 in/yr) (Intergovernmental Panel on Climate Change, 2007a). Whether the faster rate for 1993-2003 reflects decadal variability or an increase in the longer-term trend is unclear. In the structured context used by the Intergovernmental Panel on Climate Change, there is high confidence that the observed sea-level rise rate increased from the 19th to the 20th century. The average global rate for the 20th century was determined by Bindoff et al. (2007, Section 5.5.2.1) to be 1.7 ± 0.5 mm/yr and the total 20th-century average rise is estimated to be 0.17 m (0.55 ft) (Intergovernmental Panel on Climate Change, 2007a). The U.S. Global Change Research Program reported that over the last 50 years sea-level has risen up to 8 in (203 mm) along parts of the Atlantic and Gulf Coasts that included Louisiana (Karl et al., 2009, p. 37), and that global sea level is currently rising at an increasing rate.

Although absolute sea-level rise is a contributor to the total amount of sea-level rise along the Gulf Coast, subsidence is the most important contributor to the total. In comparison to other areas along the Gulf Coast, Louisiana's Mississippi Delta and Chenier Plains are built of young sediments deposited over the last 7,000 years. These deltaic sediments have been undergoing compaction and subsidence since they were deposited. The land is sinking at the same time that sea level is rising, contributing to high rates of relative sea-level rise along the Louisiana coast. Blum and Roberts (2009) posited three scenarios for subsidence and sea-level rise, and they concluded sediment starvation alone would cause ~2,286 mi^2 (592,071 ha) of the modern delta plain to submerge by 2050, without any other impacting factors contributing to landloss.

A general value of ~6 mm/yr (0.23 in) of subsidence from sediment compaction, dewatering and oxidation of organic matter (Meckel et al., 2006; Dokka, 2006) is a reasonable rate to attribute to the Louisiana coastal area, with the understanding that subsidence rates along the Louisiana coast are spatially variable and influenced by subsurface structure and the timing and manner that the delta was deposited. Applied to the entire coast, it is an oversimplification of a complex system, but it is an estimate that is reasonable based on recent data.

Stephens (2009 and 2010a) reported that the influence of subsurface structure has not been taken into account in subsidence assessments in the LCA and along the Gulf Coast (Stephens, 2009, p. 747). Most workers studying the affects of subsidence along the LCA have focused on surficial or near-surface geologic data sources and have made no attempt to integrate basin analysis into planning for coastal restoration or flood control project planning.

The BOEMRE anticipates that, over the next 40 years, the LCA will likely experience a total of relative sea-level rise of ~45 cm (18 in), or approximately 9 mm/yr (0.35 in). This estimate is made by combining the estimated rate for subsidence (~6 mm/yr) (0.23 in) and the estimated rate for absolute sea-level rise (~3 mm/yr) (0.12 in).

Formation Extraction and Subsidence

Extracting fluids and gas from geologic formations can lead to localized subsidence at the surface. Morton et al. (2005) examined localized areas or "hot spots" corresponding to fields in the LCA where oil, gas, and brine were extracted at known rates. Morton et al. (2005, Figure 26) shows measured subsidence along transects across these fields that range from 18 to 4 mm/yr (0.7 to 0.15 in), with the greatest rates tending to coincide with the surface footprints of oil or gas fields. Mallman and Zoback (2007) interpreted downhole pressure data in several Louisiana oil fields in Terrebonne Parish and found localized subsidence over the fields; however, they could not link these localized rates to the subsidence measured and observed on a regional scale.

Down-to-the-basin faulting, also called listric or growth faulting, is a long recognized structural style along deltaic coastlines, and the Mississippi Delta is no exception (Dokka et al., 2006; Gagliano, 2005a). There is currently disagreement in the literature regarding the primary cause of modern fault movement in the Mississippi Delta region, and the degree to which it is driven by fluid withdrawal or sediment compaction resulting from the sedimentary pile pressing down on soft, unconsolidated sediments that causes downward and toward the basin movement along surfaces of detachment in the shallow and deep subsurface.

Berman (2005) discussed the conclusions of Morton et al. (2005) and believed that they failed to make the case that hydrocarbon extraction caused substantial subsidence over the broader area of coastal Louisiana, a conclusion also reached by Gagliano (2005b).

Cumulative Activities Scenario: Oil production on the LCA peaked at 513 million bbl in 1970 and gas production peaked at 7.8 MMcf in 1969 (Ko and Day, 2004b). From peak the level of activity is slowly decreasing. The magnitude of subsidence caused by formation extraction is a function of how pervasive the activity is across the LCA. The oil and gas field maps in Turner and Cahoon (1988, Figure 4) and Ko and Day (2004b, Figure 1) seem an adequate basis to estimate the LCA's oil- and gas-field footprint at ~20 percent of the land area. The amount of subsidence from formation extraction is also occurring on a delta platform that is experiencing natural subsidence and sea-level rise. Fluid and gas extraction may lead to high local subsidence on the scale of individual oil and gas fields, but not as a pervasive contributor to regional subsidence across the LCA.

Mississippi River Hydromodification

Chapter 4.1.3.3.2 of the Multisale EIS and Chapter 3.3.4 of the 2009-2012 Supplemental EIS discuss river development and flood control projects on the Mississippi River. The Mississippi River has been anchored in place by engineered structures built in the 20th century and has been hydrologically isolated from the delta it built. The natural processes that allowed the river to flood and distribute alluvial sediments across the delta platform and channels to meander have been shut down. Hydromodifying interventions include construction of (1) levees along the river and distributary channel systems, (2) upstream dams and flood control structures that impound sediment and meter the river flow rate, and (3) channelized channels with earthen or armored banks. Once the natural processes that act to add sediment to the delta platform to keep it emergent are shut down, subsidence begins to outpace deposition of sediment.

Of total upstream-to-downstream flow, the Old River Control Structure (built 1963) diverts 70 percent of flow down the levee-confined channels of the Mississippi River and 30 percent down the unconfined Atchafalaya River, which has been actively aggrading its delta plain since 1973 (LaCoast.gov, 2011). Blum and Roberts reported that the time-averaged sediment load carried by the Mississippi and Atchafalaya Rivers pre-Old River Control Structure was ~400-500 million tons per year and that the average suspended load available to either river after the Old River Control Structure was ~205 million tons per year (Blum and Roberts, 2009, Figure 2). Modern sediment loads are, therefore, less than half that required to build and maintain the modern delta plain, a figure largely in agreement with previous work reporting decreases in suspended sediment load of nearly 60 percent since the 1950’s (Turner and Cahoon, 1987, Figure 3-8; Tuttle and Combe, 1981).

Blum and Roberts (2009, Figure 3b) posited three scenarios for subsidence and sea-level rise, and concluded sediment starvation alone would cause ~2,286 mi^2 (592,071 ha) of the modern delta plain to submerge by 2050 without any other impacting factors contributing to landloss. The use of sediment budget modeling, a relatively new tool for landloss assessment, appears to indicate that hydrographic modification of the Mississippi River has been the most profound man-caused influence on landloss in the LCA. Sediment starvation of the deltaic system is allowing rising sea level and subsidence to outpace the constructive processes building and maintaining the delta.

Cumulative Activities Scenario: The BOEMRE anticipates that, over the next 40 years, there might be minor sediment additions resulting from new and continuing freshwater diversion projects managed by COE. Of the 179 projects in the CWPPRA program (LaCoast.gov, 2010a), 27 involve introduction of sediment or reestablishment of natural water and sediment flow regimes to allow the delta plain to replenish and build up 10 are freshwater diversion projects, 5 are outfall management, 1 is sediment diversion, and 16 are marsh creations. Insofar as these projects represent land additions to the LCA, they are already accounted for in the discussion below under coastal restoration programs.

Maintenance Dredging and Federal Channels

Chapter 4.1.3.3.3 of the Multisale EIS and Chapter 3.3.4 of the 2009-2012 Supplemental EIS discuss maintenance dredging.

There are 10 Federal navigation channels in the LCA, ranging in depth from 4 to 14 m (12 to 45 ft) and in width from 38 to 300 m (125 and 1,000 ft) that were constructed as public works projects beginning in the 1800’s (Good et al., 1995, Table 1). The combined length of the Federal channels in Good et al. was reported as 2,575 mi (1,600 km) with three canals considered deep-draft and seven as shallow (Good et al., 1995, p. 9). The Multisale EIS (USDOI, MMS, 2007b, p. 4-316) reported 1,243 mi (2,000 km) of OCS-related navigation channels. The Federal navigation channels in Louisiana identified by Good et al. (1995, Table 1) are as follows: (1) GIWW East of Mississippi River; (2) Mississippi River Gulf Outlet; (3) GIWW between the Atchafalaya and Mississippi Rivers; (4) GIWW West of Atchafalaya River; (5) Barataria Bay Waterway; (6) Bayou Lafourche; (7) Houma Navigation Canal; (8) Mermentau Navigation Channel; (9) Freshwater Bayou; and (10) Calcasieu River Ship Channel.

Turner and Cahoon (1987, Table 4-1) and DOI (USDOI, MMS, 2007b, Table 3-36) identified OCS-related channels that bore traffic supporting the OCS Program. Between these works and Good et al. (1995, Table 1) channel names do not well agree and a comparison is difficult. No channel is exclusively used by OCS Program traffic and only a fraction of total traffic is attributable to OCS use; approximately 12 percent (USDOI, MMS, 2007b, p. 4-316). The BOEMRE staff compiled **Table 3-15** using the

information in industry plans to show that, between 2003 and 2008, the vast majority (80-90%) of OCS service vessels used service-base facilities in the LCA that are located along rivers or that lie within wetlands that are already saline or brackish. **Table 3-15** shows that the contribution of OCS Program traffic to bank degradation and freshwater wetland loss is minimal.

The GIWW is a Federal, shallow-draft navigation channel constructed to provide a domestic connection between Gulf ports after the discovery of oil in East Texas in the early 1900's, as well as the growing need for interstate transport of steel and other manufacturing materials. It extends approximately 1,400 mi (2,253 km) along the Gulf Coast from St. Marks in northwestern Florida to Brownsville, Texas, with the Louisiana part reported to be 994 mi (1,600 km) in length (Good et al., 1995, p. 9). With the exception of the east-west GIWW in Louisiana, Federal channels are sub-perpendicular with the GOM shoreline or saltwater bays, making them vulnerable to saltwater intrusion during storms.

Direct cumulative impacts include the displacement of wetlands by original channel excavation and disposal of the dredged material. Good et al. (1995, Table 1) estimated that direct impacts from the construction of Federal navigation channels were between 58,000 and 96,000 ac (23,472 and 38,850 ha). Indirect cumulative landlosses resulted from hydrologic modifications, saltwater intrusion, or bank erosion from vessel wakes (Wang, 1988). Once cut, navigation canals tend to widen as banks erode and subside, depending on the amount of traffic using the channel. Good et al. (1995, Table 1) estimated indirect impacts on wetland loss from bank erosion at 35,000 ac (14,164 ha).

The COE reported that the New Orleans District has the largest channel maintenance dredging program in the U.S., with an annual average of 70 million yd^3 of material dredged (U.S. Dept. of the Army, COE, 2009a, p. 26). Of that total, COE's Ocean Disposal Database indicates that about 16 million yd^3 were disposed at ODMDS sites by the New Orleans District (U.S. Dept. of the Army, COE, 2011a) (**Chapter 3.3.3**). Federal channels and canals are maintained throughout the onshore cumulative impact area by COE, State, county, commercial, and private interests. Proposals for new and maintenance dredging projects are reviewed by COE, State, and local agencies as well as by private and commercial interests to identify and mitigate adverse impacts upon social, economic, and environmental resources.

Maintenance dredging is performed on an as-needed basis. Typically, COE schedules surveys every 2 years on each navigation channel under its responsibility to determine the need for maintenance dredging. Dredging cycles may be from 1 to as many as 11 years from channel to channel and from channel segment to channel segment. The COE is charged with maintaining all larger navigation channels in the cumulative activities area. The COE dredges millions of cubic meters of material per year in the cumulative activities area, most of which is under the responsibility of the New Orleans District. Some shallower port-access channels may be deepened over the next 10 years to accommodate deeper draft vessels. Vessels that support deepwater OCS activities may include those with drafts to about 7 m (23 ft).

Construction and maintenance dredging of rivers, navigation channels, and pipeline access canals can furnish sediment for beneficial purpose, a practice the COE calls beneficial use of dredge materials program. Drilling, production activity, and maintenance at most coastal well sites in Louisiana require service access canals that undergo some degree of aperiodic maintenance dredging to maintain channel depth, although oil and gas production on State lands peaked in 1969-1970 (Ko and Day, 2004b, p. 398). In recent years, dredged materials have been sidecast to form new wetlands using the beneficial use of dredge materials program. Potential areas suited for beneficial use of dredged material are considered most feasible within a 10-mi (16-km) boundary around authorized navigation channels in the New Orleans District, but the potential for future long distance pipelines for disposal of dredged material could increase the potential area available for the beneficial use of dredge materials program considerably (U.S. Dept. of the Army, COE, 2009a, p. 27).

Current figures vary for how much of the average annual 70 million yd^3 (53,518,840 m^3) that is dredged by the New Orleans District is available for the beneficial use of dredge materials program: from 15 million yd^3 (11,468,320 m^3) (U.S. Dept. of the Army, COE, 2009a, p. 26) to 30 million yd^3 (22,936,650 m^3) (Green, 2006, p. 6), or between 21 and 43 percent of the total. The COE reported that, over the last 20 years, approximately 10,117 ha (25,000 ac) of wetlands have been created with dredged materials, most of which are located on the LCA delta plain (U.S. Dept. of the Army, COE, 2009c, p. 8).

Cumulative Activities Scenario: The construction of Federal channels is not a growth industry and at least one Louisiana channel (Mississippi River Gulf Outlet) has been decommissioned and sealed with a rock barrier as of July 2009 (Shaffer et al., 2009, p. 218). The DOI has used a widening rate for OCS-

related channels of 1.5 m/yr (4.9 ft/yr) (USDOI, MMS, 2007b, p. 4-316). Using DOI's estimate of 2,000,000 m (1,243 mi) of OCS-related channel length (USDOI, MMS, 2007b, p. 4-316) and the estimated bank widening rate of 1.5 m/yr (5 ft/yr) for OCS-related channels, an annual landloss of ~741 ac/yr (300 ha/yr) may be estimated. During the 40-year cumulative activities scenario, landloss from indirect impacts on Federal navigation channels could be ~29,653 ac (12,000 ha). The use of Federal channels by OCS-related traffic is ~12 percent of total capacity, and an estimate may be made for the OCS Program's contribution to bank erosion over the 40 year cumulative scenario of 355 ha (877 ac).

The BOEMRE anticipates that, over the next 40 years, if current trends in use of dredged sand and sediment for the beneficial use of dredge materials program are simply projected based on past land additions and if there is no change in the average annual rate of wetland creation or protection with this program, approximately ~50,000 ac (20,234 ha) may be created or protected in the LCA. Subtracting projected land added from land lost, an estimated net landloss of ~9,419 ha (23,274 ac) between the years 2007-2046 could occur between land lost by bank degradation and channel widening and land added using the beneficial use of dredge materials program.

Coastal Restoration Programs

Chapter 4.1.3.3.4 of the Multisale EIS and Chapter 3.3.5 of the 2009-2012 Supplemental EIS discuss coastal restoration. The Mississippi Delta sits atop a pile of Mesozoic and Tertiary-aged sediments up to 7.5 mi (12.2 km) thick at the coast and it may be as much as 60,000 ft (18,288 m) or 11.4 mi (18.3 km) thick offshore (Gagliano, 1999). Five major lobes are generally recognized within about the uppermost 50 m (164 ft) of sediments (Britsch and Dunbar, 1993; Frazier, 1967, Figure 1). The oldest lobe contains peat deposits dated as 7,240 years old (Frazier, 1967, p. 296). The youngest delta lobe of the Mississippi Delta is the Plaquemines-Balize lobe that has been active since the St. Bernard lobe was abandoned about 1,000 years ago. The lower Mississippi River has shifted its course to the Gulf of Mexico every thousand years or so, seeking the most direct path to the sea while building a new deltaic lobe. Older lobes were abandoned to erosion and subsidence as the sediment supply was shut off. Because of the dynamics of delta building and abandonment, the Louisiana coastal area (U.S. Dept. of the Army, COE, 2004a) experiences relatively high rates of subsidence relative to more stable coastal areas eastward and westward.

The first systematic program authorized for coastal restoration in the LCA was the 1990 Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), otherwise known as the "Breaux Act." Individual CWPPRA projects are designed to protect and restore between 10 and 10,000 ac (4 and 4,047 ha), require an average of 5 years to transition from approval to construction, and are funded to operate for 20 years (U.S. Government Accountability Office, 2007, p. 2), a typical expectation for project effectiveness (Campbell et al., 2005, p. 245).

The 1990 CWPPRA introduced an ongoing program of relatively small projects to partially restore the coastal ecosystem. As the magnitude of Louisiana's coastal landlosses and ecosystem degradation became more apparent, so too appeared the need for a more systematic approach to integrate smaller projects with larger projects to restore natural geomorphic structures and processes. The Coast 2050 report (Louisiana Dept. of Natural Resources, 1998) combined previous restoration planning efforts with new initiatives from private citizens, local governments, State and Federal agency personnel, and the scientific community to converge on a shared vision to sustain the coastal ecosystem. The LCA Ecosystem Restoration Study (U.S. Dept. of the Army, COE, 2004a) built upon the Coast 2050 Report. The LCA's restoration strategies generally fell into one of the following categories: (1) freshwater diversion; (2) marsh management; (3) hydrologic restoration; (4) sediment diversion; (5) vegetative planting; (6) beneficial use of dredge material; (7) barrier island restoration; (8) sediment/nutrient trapping; and (9) shoreline protection, as well as other types of projects (Louisiana Coastal Wetlands Conservation and Restoration Task Force, 2006, Table 1).

Following Hurricanes Katrina and Rita in 2005, an earlier emphasis on coastal or ecosystem restoration of the LCA was reordered to at least add an equal emphasis on hurricane flood protection. In late 2005, the Department of Defense Appropriations Act of 2006 authorized COE to develop a comprehensive hurricane protection analysis to present a full range of flood control, coastal restoration, and hurricane protection measures for south Louisiana (U.S. Dept. of the Army, COE, 2009b). The Appropriations Act required Louisiana to create a State organization to sponsor the hurricane protection

and restoration projects that resulted. The State legislature established the Coastal Protection and Restoration Authority and charged it with coordinating the efforts of local, State, and Federal agencies to achieve long-term, integrated flood control and wetland restoration. The Coastal Protection and Restoration Authority produced a comprehensive master plan for a sustainable coast (State of Louisiana, 2007) as their vision of an integrated program of what had been separate areas of activity—flood protection and coastal restoration. The Coastal Protection and Restoration Authority's Annual Plans prioritize the types of projects undertaken each fiscal year. It is not entirely clear how coordination between the State and Federal authorities is undertaken in order to develop the range of projects selected for the State's Coastal Protection and Restoration Authority's Annual Plan and COE's plan (U.S. Dept. of the Army, COE, 2009a, Figures 17-1, 17-2, and 17-3).

The U.S. Government Accountability Office (GAO) recently audited the CWPPRA Program (U.S. Government Accountability Office, 2007). The GAO reported 74 completed CWPPRA projects between 1994 and 2007 that resulted in 58,781 "anticipated total acres" (23,788 ha) and 16 projects under construction as of mid-2007 that are reported to result in 20,860 anticipated total acres (8,442 ha) (U.S. Government Accountability Office, 2007, Tables 2 and 3). Of the 74 projects constructed since 1994, more than half were one of two types—shoreline protection or hydrologic restoration. Of the 179 CWPPRA priority projects listed on LaCoast.gov (2010b), 55 projects with 31,187 ac (12,621 ha) "total net acres" (defined as the sum of reestablished and protected acres present at the end of 20 years) are not found on GAO's completed or underway lists (U.S. Government Accountability Office, 2007, Tables 2 and 3), leading to a conclusion that these projects are in line for completion before 2019.

Cumulative Activities Scenario: The BOEMRE's anticipates that, over the next 40 years, ~12,621 ha (31,187 ac) of land would be added, or 316 ha/yr (781 ac/yr) between now and 2019. This estimate is based in the assumption that the full menu of 179 CWPPRA projects now anticipated (LaCoast.gov, 2010b) are completed by the end of the authorization period in 2019.

There is no simple way to anticipate what projects under the protection of the State's Coastal Protection and Restoration Authority are admitted to its Annual Plan and completed. There is also no simple way to anticipate what projects are undertaken for COE's comprehensive range of flood control, coastal restoration, and hurricane protection measures for the LCA will feed into the Coastal Protection and Restoration Authority's Annual Plan for authorization and which ones will be ultimately completed. Because these projects are chosen on the basis of annual appropriations, there is no simple way to establish projections for land added or preserved over the cumulative activities scenario.

Coastal Impact Assistance Program

The Energy Policy Act of 2005 was signed into law by President Bush on August 8, 2005. Section 384 of EPAct amended Section 31 of the OCSLA (43 U.S.C. 1356(a)) to establish the Coastal Impact Assistance Program (CIAP). The authority and responsibility for the management of CIAP is vested in the Secretary of the Interior; the Secretary delegated this authority and responsibility to this Agency. Under EPAct Section 384, this Agency was directed to disburse $250 million for each of the fiscal years (FY) 2007 through 2010 to eligible OCS oil- and gas-producing States and coastal political subdivisions (CPS's).

Eligible CIAP States	Eligible CIAP Coastal Political Subdivisions
Alabama	Baldwin and Mobile Counties
Alaska	Municipality of Anchorage and Bristol Bay, Kenai Peninsula, Kodiak Island, Lake and Peninsula, Matanuska-Susitna, North Slope, and Northwest Arctic Boroughs
California	Alameda, Contra Costa, Los Angeles, Marin, Monterey, Napa, Orange, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, and Ventura Counties
Louisiana	Assumption, Calcasieu, Cameron, Iberia, Jefferson, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Martin, St. Mary, St. Tammany, Tangipahoa, Terrebonne, and Vermilion Parishes
Mississippi	Hancock, Harrison, and Jackson Counties
Texas	Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Harris, Jackson, Jefferson, Kenedy, Kleberg, Matagorda, Nueces, Orange, Refugio, San Patricio, Victoria, and Willacy Counties

The funds allocated to each State are based on the proportion of qualified OCS revenues (QOCSR) offshore the individual State to total QOCSR from all States. The EPAct requires a minimum allocation of 1 percent to each State and provides that 35 percent of each State's allocation be shared by its CPS's. **Table 3-16** shows the allocation of CIAP funds by fiscal year to each of the six eligible States and 67 eligible CPS's.

A State, in cooperation with its CPS's, must submit to BOEMRE for approval a CIAP State Plan (Plan) that describes how it will spend its CIAP funds. A State or CPS shall use all amounts received under CIAP for one or more of the following purposes: (1) projects and activities for the conservation, protection, or restoration of coastal areas, including wetland; (2) mitigation of damage to fish, wildlife, or natural resources; (3) planning assistance and the administrative costs of complying with this section; (4) implementation of a federally approved marine, coastal, or comprehensive conservation management plan; and (5) mitigation of the impact of OCS activities through funding of onshore infrastructure projects and public service needs.

Once a Plan is approved, a State and its CPS's are eligible to submit grant applications for the projects described in its Plan. All six States have approved Plans. Currently, Alaska, California, Louisiana, and Mississippi have approved FY 2007-2010 Plans and are eligible to submit grant applications for their FY 2007-2010 allocated funds. Alabama has an approved FY 2007-2008 Plan and therefore may only submit grant applications for its FY 2007-2008 funds, while Texas has an approved FY 2007 Plan and may only submit grant applications for its FY 2007 funds. From total allocated funds, **Table 3-17** shows the dollar amount of CIAP funds applied for, awarded, under review, and remaining for each Gulf State and CPS.

The Gulf Coast Ecosystem Restoration Task Force

The Gulf Coast Ecosystem Restoration Task Force was set up by an Executive Order signed by President Obama on October 5, 2010 (The White House, 2010). The Task Force stated the Federal Government's desire to address longstanding ecological decline and begin moving toward a more resilient Gulf Coast ecosystem, especially in the aftermath of the DWH event. The Executive Order expressed the Federal Government's commitment to help residents conserve and restore resilient and healthy GOM ecosystems that support and sustain the diverse economies, communities, and cultures of the region and the important national missions carried out in the GOM.

The specific goals of the Task Force are to support economic vitality, enhance human health and safety, protect infrastructure, enable communities to better withstand impact from storms and climate change, sustain safe seafood and clean water, provide recreational and cultural opportunities, protect and preserve sites that are of historical and cultural significance, and contribute to the overall resilience of coastal communities. To support and enable these goals, the Task Force's role is to coordinate intergovernmental responsibilities, planning, and exchange of information so as to better implement ecosystem restoration and to facilitate appropriate accountability and support throughout the restoration process. The Executive Order directed Federal efforts to be efficiently integrated with those of local

stakeholders, and that particular focus should be toward innovative solutions for complex, large-scale restoration projects. The Executive Order seeks science-based and well-coordinated solutions that minimize duplication and ensure effective delivery of services.

The Executive Order explicitly identified the following Federal agencies and groups as participating in Task Force: (1) Department of Defense; (2) Department of Justice; (3) Department of the Interior; (4) Department of Agriculture; (5) Department of Commerce; (6) Department of Transportation; (7) Environmental Protection Agency; (8) Office of Management and Budget; (9) Council on Environmental Quality; (10) Office of Science and Technology Policy; (11) Domestic Policy Council; and (12) other executive departments, agencies, and offices as the President may, from time to time, designate. In addition to these designated Federal participants, representatives of the five Gulf Coast States may be appointed by the President upon recommendation of the Governors of each state. These representatives are to be elected officers of State governments (or their designated employees with authority to act on their behalf) acting in their official capacities. The Task Force may include representatives from affected tribes, who are elected officers of those tribes (or their designated employees with authority to act on their behalf) acting in their official capacities. The Task Force shall, in collaboration with affected tribes, determine an appropriate structure for tribal participation in matters within the scope of the Task Force's responsibilities. No State or tribal representatives have yet been identified for the Task Force.

The Task Force held its inaugural meeting on November 8, 2010, at the Pensacola Civic Center in Pensacola, Florida. Attendees were reported as numbering approximately 250. The meeting was chaired by Ms. Lisa Jackson, USEPA Administrator, for whom the Task Force serves. The agency representatives for the federally designated agencies and groups introduced themselves as did the staff director for the Task Force. Pre-meeting materials provided to participants who had responded to an open and widely distributed announcement and invitation were provided with the two orders of business that Ms. Jackson wished the first meeting to focus upon.

(1) How in the coming months can the Task Force best enable the widest possible participation in this process? How can the Task Force best connect to keep everyone informed and to ensure good two-way communication?

(2) Which of the many critical substantive issues about restoration should the Task Force focus on first? Which ones rise to the top for immediate attention knowing that all of them will be eventually have to be addressed?

Assistant Secretary for Fish and Wildlife and Parks (at that time Thomas Strickland) was the point of contact for DOI's involvement in the Task Force. Mr. Strickland reported that, as of November 8, 2010, 9,000 people were still employed in spill cleanup activity; 3,000 DOI staff had, at one time or another, been involved in spill response or cleanup activity; and 580 mi (933 km) of shoreline were still undergoing cleaning activities. The BOEMRE sent six staff scientists to attend the November 8 meeting, but this Agency is not now identified as a participant.

Some of the insights gathered at the first Task Force meeting are as follows: (1) the Task Force wanted to receive as much bottoms-up input as they could so that they could formulate how they think the Task Force would operate; (2) there is no current budget for the Task Force and the staff conducting the work supported by their host agencies, and (3) the outputs are not yet defined. At this early point, the Task Force appears to view their role as coordination and information sharing for already approved or established planning efforts, such as coastal restoration projects administrated by COE and the State of Louisiana, or the CIAP administered by BOEMRE.

Ms. Jackson's closing remarks stated that Task Force members and staff were now obligated to answer the many questions elicited from the inputs requested by Ms. Jackson's two orders of business for the first meeting. Much useful input was received on Ms. Jackson's question, "How can the Task Force best connect to keep everyone informed and to ensure good two-way communication?" The inputs received on question 2, "What should the Task Force focus on first?" was very general and conceptual and did not seem to elicit as much useful information for the Task Force's next steps. The Task Force has a website (www.restorethegulf.com) to keep observers aware of its activities.

3.3.5. Natural Events or Processes

3.3.5.1. Hurricanes

Chapter 3.3.5.7.3 of the Multisale EIS and Chapter 3.1.1.5.3 of the 2009-2012 Supplemental EIS discuss damage to infrastructure from recent hurricanes. Climatic cycles in tropical latitudes typically last 20-30 years, or even longer (USDOC, NOAA, 2005). As a result, North Atlantic experiences alternating periods of above-normal or below-normal hurricane seasons. There is a two- to three-fold increase in hurricane activity during eras of above-normal activity. The hurricane activity from 1995 to 2007 is representative of an era of above-normal hurricane activity (Elsner et al., 2008, p. 1,210).

Seventeen hurricanes made landfall in the WPA or CPA during the 1995-2009 hurricane seasons, disrupting OCS oil and gas activity in the GOM (**Table 3-18**). Half of these hurricanes reached a maximum strength of Category 1 or 2 while in the CPA or WPA, while the other half were powerful hurricanes reaching maximum strengths of Categories 4 or 5. The current era of heightened Atlantic hurricane activity began in 1995; therefore, the GOM could expect to see a continuation of above-normal hurricane activity during the first 10-20 years of the 40-year analysis period and below-normal activity during the remaining 20-30 years of the 40-year analysis period.

Hurricanes Ivan, Katrina, Rita, Gustav, and Ike caused extensive damage to OCS platforms, topside facilities, and pipeline systems (**Table 3-19).** During Hurricanes Ivan, Katrina, and Rita, 9 jack-up rigs and 19 moored rigs were either toppled or torn from their mooring systems. Sixty platforms were destroyed as a result of Hurricanes Gustav and Ike in 2008.

After the 2005 hurricanes, this Agency set forth guidance to ensure compliance with 30 CFR 250.417 and to improve performance in the area of jack-up and moored rig station-keeping during the environmental loading that may be experienced during hurricanes. Industry, USCG, and this Agency worked together to develop interim recommended practices for the use of jack-up and moored rigs during the future hurricane seasons to potentially decrease the amount of failures during hurricanes. This Agency issued NTL 2006-G10, “Moored Drilling Rig Fitness Requirements for the 2006 Hurricane Season,” and NTL 2006-G09, “Jack-up Drilling Rig Fitness Requirements for the 2006 Hurricane Season.” These NTL’s provide guidance on the information operators must submit with the application for permit to drill to demonstrate the fitness of any jack-up or moored drilling rig to conduct drilling, workover, or completion operations in the Gulf of Mexico OCS during the 2006 hurricane season, and beyond, that remain applicable until revised. These NTL’s represent a small part of the response to review and provide guidance to operators for MODU requirements and reporting in light of the recent experiences from damage caused by recent hurricanes.

3.3.5.2. Currents as Transport Agents

Physical oceanographic processes in the GOM contributing to the distribution of spilled oil include the Loop Current, Loop Current eddies, and whirlpool-like features underneath the LC and LCE’s that interact with the bottom. Infrequently observed processes include a limited number of high-speed current events, at times approaching 100 cm/s (39 in/s). These events were observed at depths exceeding 1,500 m (4,921 ft) in the northern GOM (Hamilton and Lugo-Fernandez, 2001; Hamilton et al., 2003) and as very high-speed currents in the upper portions of the water column observed in deep water by several oil and gas operators. All of these processes are described in Appendix A.2 of the Multisale EIS. Generally, current speed in the deep GOM has been observed to decrease with depth. Mean deep flow around the edges of the GOM circulates in a counterclockwise direction at ~2,000 m (6,562 ft) (Sturges et al., 2004) and at ~900 m (2,953 ft) (Weatherly, 2004).

Mean seasonal circulation patterns of inner-shelf and outer-shelf currents on the Louisiana-Texas continental shelf, the northeastern GOM shelf, and the West Florida shelf are described in Appendix A.2 of the Multisale EIS. These currents are primarily wind driven and are also influenced by riverine outflow. Cold water from deeper off-shelf regions moves onto and off the continental shelf by cross-shelf flow associated with upwelling and downwelling processes in some locations (Collard and Lugo-Fernandez, 1999). Wind events such as tropical cyclones (especially hurricanes), extratropical cyclones, and cold-air outbreaks can result in extreme waves and cause currents with speeds of 100-150 cm/s (39-59 in/s) over continental shelves. Wave heights of 91 ft (28 m) were measured during the passage of Hurricane Ivan through the northern GOM (Wang et al., 2005).

The physical oceanography of the GOM, and the natural processes that may influence the cumulative activities scenario, was discussed in Chapter 3.3.7.1 of the 2009-2012 Supplemental EIS. Since that time, several new reports on circulation of the Gulf's deep waters have been completed. The main findings from such studies are as follows: (1) the deep Gulf can be approximated as a two-layer system with an upper layer about 800- to 1,000-m (2,625- to 3,281-ft) thick that is dominated by the Loop Current and associated clockwise whirlpools (Cox et al., in press; Welsh et al., 2009; Inoue et al., 2008); (2) the lower layer below ~1,000 m (3,281 ft) has near uniform currents (Cox et al., in press; Welsh et al., 2009; Inoue et al., 2008); (3) the coupling between these two layers is generally absent, but it seems that motions of the layer interface are needed to transmit the energy from the Loop Current and eddies downward (Cox et al., in press; Welsh et al., 2009; Inoue et al., 2008, Donohue et al., 2008); (4) there is a wealth of secondary whirlpools with smaller diameters (50-100 km; 31-62 mi) that affect the exchange between the shelf and deepwater, and these smaller whirlpools interact with the larger Loop eddies (Donohue et al., 2008); and (5) the ocean's response to tropical storms and hurricanes is similar to that reported previously, but a new mode was found to transport the hurricane's energy downward related to the sea-level rise near the storm eye (Welsh et al., 2009; Cole and DiMarco, 2010).

Caribbean Sea waters colliding with the Yucatan Peninsula turn northward and enter the Yucatan Channel as a strong flow called the Yucatan Current. This current exhibits two basic arrangements inside the GOM. First, the Yucatan Current enters the Gulf and turns immediately eastward, exiting the Gulf towards the Atlantic Ocean via the Florida Straits to become the Gulf Stream. The second arrangement consist of a northward penetration of the Yucatan Current into the Gulf reaching to 26º-28ºN latitudes, then curls clockwise turning south, and exiting via the Florida Straits into the Atlantic Ocean to become, again, the Gulf Stream. The stream inside the Gulf is called the Loop Current. The Loop Current transports warm and salty water year round into the GOM at a rate of 25-30 million cubic meters per second, and it is the main energy source for oceanographic processes inside the Gulf. At its climatic northern position, the Loop becomes unstable, breaks, and sheds a large (200- to 400-km diameter [124- to 248-mi diameter]) clockwise whirlpool that travels southwestwards at speeds of 4-8 km/day (2-5mi/day). The southwest trip of Loop Current eddies continues until colliding with the Texas and Mexico continental slope in the western GOM, where they disintegrate. This sequence connects the eastern with the western Gulf, which otherwise appear disconnected.

CHAPTER 4

DESCRIPTION OF THE ENVIRONMENT AND IMPACT ANALYSIS

4. DESCRIPTION OF THE ENVIRONMENT AND IMPACT ANALYSIS

The impacts of 11 WPA and CPA sales were analyzed in the Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222, Final Environmental Impact Statement (Multisale EIS; USDOI, MMS, 2007b). An analysis of the routine, accidental, and cumulative impacts of a WPA or CPA proposed action on the environmental and socioeconomic resources of the Gulf of Mexico can be found in Chapters 4.2, 4.4, and 4.5 of the Multisale EIS, respectively. The Multisale EIS was supplemented by the Gulf of Mexico OCS Oil and Gas Lease Sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218; Final Supplemental Environmental Impact Statement (2009-2012 Supplemental EIS; USDOI, MMS, 2008a) and included an analysis on the 181 South Area that was made available for leasing through the Gulf of Mexico Energy Security Act of 2006. An analysis of the routine, accidental, and cumulative impacts of a CPA or WPA proposed action on the environmental and socioeconomic resources of the Gulf of Mexico can be found in Chapter 4 of the 2009-2012 Supplemental EIS. The Multisale EIS and the 2009-2012 Supplemental EIS are hereby incorporated by reference.

The purpose of this Supplemental EIS is to determine if new information is substantial enough to alter the conclusions stated in the Multisale EIS and the 2009-2012 Supplemental EIS and, if so, to disclose those changes. This includes all new information and not just that acquired since the DWH event. This Supplemental EIS was prepared in consideration of the potential changes to the baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of the DWH event. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS also considered the DWH event in the analysis of the potential alternatives of the proposed action.

It must be understood that this Supplemental EIS analyzes the proposed action and alternatives for the proposed CPA lease sale. This is not an EIS on the DWH event, although information on this event is being analyzed as it applies to resources in the CPA.

4.1. Proposed Central Planning Area Lease Sale 216/222

Proposed CPA Lease Sale 216.222 is scheduled to be held in 2012. The CPA lease sale area encompasses about 63 million ac of the CPA's 66.3 million ac located 3 nmi offshore Louisiana, Mississippi, and Alabama and extends seaward to the limits of the EEZ in water depths up to 3,458 m (11,345 ft) (**Figure 1-1**). This proposed CPA lease sale would offer for lease all unleased blocks in the CPA for oil and gas operations (**Figure 1-1**), with the following exceptions:

(1) blocks directly south of Florida and within 100 mi of the Florida coast (north of the easternmost portion of the CPA sale area as shown on **Figure 1-1**);

(2) blocks that are beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap.

Chapter 4.1 presents baseline data for the physical, biological, and socioeconomic resources that would potentially be affected by proposed CPA Lease Sale 216/222 or the alternatives, and it presents analyses of the potential impacts of routine events, accidental events, and cumulative activities on these resources. Baseline data are considered in the assessment of impacts from proposed CPA Lease Sale 216/222 on these resources.

During the past few years, the Gulf Coast States and GOM oil and gas activities have been impacted by several major storms and hurricanes. Appendix A.3 of the Multisale EIS provides information on Hurricanes Lili (2002), Ivan (2004), Katrina (2005), and Rita (2005). In 2008, Hurricanes Gustav and Ike also impacted OCS infrastructure **(Chapter 3.3.7.2)**. The description of the affected environment below includes impacts from these storms on the physical, biological, and socioeconomic resources.

The DWH event off the Louisiana coast resulted in the largest oil spill in U.S. history. Approximately 4.9 million barrels flowed into the Gulf over a period of 87 days. An event such as this has the potential to adversely affect multiple resources over a large area. The level of adverse effect depends on many factors, including the sensitivity of the resource. All effects may not initially be seen and some could take years to fully develop. The analyses of impacts from the DWH event on the physical, biological, and socioeconomic resources below are based on information known at this time. However, the effects of proposed CPA Lease Sale 216/222 on these resources are expected to be substantially the same as those presented in the Multisale EIS, even when considered in the context of the DWH event. The BOEMRE will continue to monitor these resources for effects caused by the DWH event.

Chapter 4.1.3.4.4 of the Multisale EIS provides information on accidental spills that could result from all operations conducted under the OCS Program, as well as information on the number and sizes of spills from non-OCS sources. The number of spills ≥1,000 bbl and >10,000 bbl estimated to occur as a result of the CPA proposed action is provided in **Table 3-5**. The mean number of spills estimated for the proposed action in the CPA is 1-3 spills (≥1,000 bbl) and <1-1 spill (≥10,000 bbl). Figure 4-12 of the Multisale EIS provides the probability of a particular number of offshore spills ≥1,000 bbl occurring from facility or pipeline operations in the CPA. Spill rates for all of the spill-size categories are provided in Table 4-16 of the Multisale EIS. The probabilities of a spill ≥1,000 bbl occurring and contacting modeled environmental resources are described in Chapter 4.3.1.5.7 and Figures 4-14 through 4-31 of the Multisale EIS.

The potential impacts of a low-probability, large oil-spill event, such as the DWH event, to the environmental resources and socioeconomic conditions listed above are fully addressed in the "Catastrophic Spill Event Analysis" (**Appendix B**). The reader is referred to **Appendix B** for the analysis of a potential effect of a catastrophic event for each resource.

The following cumulative analyses consider impacts to physical, biological, and socioeconomic resources that may result from the incremental impact of proposed CPA Lease Sale 216/222 when added to all past, present, and reasonably foreseeable future human activities, including non-OCS activities, as well as all OCS activities (OCS Program). Non-OCS activities include, but are not limited to, import tankering; State oil and gas activity; recreational, commercial, and military vessel traffic; offshore LNG activity; recreational and commercial fishing; onshore development; and natural processes. The OCS Program scenario includes all activities that are projected to occur from past, proposed, and future lease sales during the 40-year analysis period (2007-2046). This includes projected activity from lease sales that have been held, but for which exploration or development has not yet begun or is continuing.

Analytical Approach

The analyses of potential effects to the wide variety of physical, environmental, and socioeconomic resources in the vast area of the GOM and adjacent coastal areas is very complex. Specialized education, experience, and technical knowledge are required, as well as familiarity with the numerous impact-producing factors associated with oil and gas activities and other activities that can cause cumulative impacts in the area. Knowledge and practical working experience of major environmental laws and regulations such as NEPA, the Clean Water Act, CAA, CZMA, ESA, MMPA, the Magnuson-Stevens Fishery Conservation and Management Act, and others is also required.

In order to accomplish this task, BOEMRE has assembled a multidisciplinary staff with hundreds of years of experience. The vast majority of this staff has advanced degrees with a high level of knowledge related to the particular resources discussed in this chapter. This staff prepares the input to BOEMRE's lease sale EIS's, a variety of subsequent postlease NEPA reviews, and are also involved with ESA, EFH, and CZMA consultations. In addition, this same staff is also directly involved with the development of studies conducted by BOEMRE's Environmental Studies Program. The results of these studies feed directly into our NEPA analyses. To date, since 1973, approximately $251 million has been spent on physical, environmental, and socioeconomic studies in the Gulf of Mexico OCS Region. There are currently 96 ongoing studies in the Gulf of Mexico OCS Region, at a cost of about $46 million. A great deal of baseline knowledge about the GOM and the potential effects of oil and gas activities are the direct result of these studies. In addition to the studies staff, BOEMRE also has a Scientific Advisory

Committee consisting of recognized experts in a wide variety of disciplines. The Scientific Advisory Committee has input to the development of the Environmental Studies Program on an ongoing basis.

For each lease sale EIS, a set of assumptions and a scenario are developed, and impact-producing factors that could occur from routine oil and gas activities, as well as accidental events, are described. This information is discussed in detail in **Chapter 3**. Using this information, the multidisciplinary staff described above applies their knowledge and experience to conduct their analyses of the potential effects of the proposed lease sale.

The conclusions developed by the subject-matter experts regarding the potential effects of the proposed lease sale for most resources are necessarily qualitative in nature; however, they are based on the expert opinion and judgment of highly trained subject-matter experts. This staff approaches this effort in good faith utilizing the best information available to them. Over the years, a suite of lease stipulations and mitigation measures has been developed to eliminate or ameliorate potential environmental effects. In many instances, these were developed in coordination with other natural resource agencies such as NOAA and FWS. It must also be emphasized that, in arriving at the overall conclusions for certain environmental resources (e.g., coastal and marine birds, fisheries, and wetlands), the conclusions are not based on impacts to individuals, small groups of animals, or small areas of habitat, but on impacts to the resources/populations as a whole.

The BOEMRE has made conscientious efforts to comply with the spirit and intent of NEPA, to avoid being arbitrary and capricious in its analyses of potential environmental effects, and to use adaptive management to respond to new developments related to the OCS Program.

Incomplete or Unavailable Information

In the following analyses of physical, environmental, and socioeconomic resources, there are numerous references to incomplete or unavailable information, especially in relation to the DWH event and the associated oil spill. The subject-matter experts for each resource used the best information that was publicly available at the time this Supplemental EIS was written to prepare the descriptions of the affected environment and impact analyses, and to develop conclusions regarding the various resources. Since this is a supplemental document tiered from the Multisale EIS and the 2009-2012 Supplemental EIS, the subject-matter experts were tasked with determining if the conclusions made in the Multisale EIS and the 2009-2012 Supplemental EIS had changed based upon new information.

Although there has been considerable speculation in media reports regarding the impacts of the DWH event, credible scientific data regarding the potential short-term and long-term impacts is incomplete and it could be many years before this information becomes available via the NRDA process, the BOEMRE Environmental Studies Program, and numerous studies by academia. Information will become available on a continuing basis for years via the NRDA process, the BOEMRE Environmental Studies Program, and numerous studies by academia.

The data obtained to support the conclusions within this Supplemental EIS indicate that, even though the environmental baseline in the CPA was changed by the DWH event, the expected level of impacts to the physical, environmental, and socioeconomic resources due to proposed CPA Lease Sale 216/222 are substantially the same as those presented in the Multisale EIS and the 2009-2012 Supplemental EIS, the documents from which this Supplemental EIS is tiered. There is no reason to believe that any additional information would alter the conclusions.

In accordance with NEPA Section 1502.22, "Incomplete or Unavailable Information," when an agency is evaluating reasonably foreseeable, significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information, the agency shall always make it clear that such information is lacking. It must be emphasized that BOEMRE is unaware of any missing data that are key to the overall analyses and conclusions regarding the potential impacts of proposed CPA Lease Sale 216/222.

Four previous CPA lease sales in the current 5-Year OCS Program (2007-2012) have already been held based on the information and analyses presented in the EIS's from which this Supplemental EIS is tiered. The conclusions of this Supplemental EIS are fundamentally the same as the conclusions upon which those lease sales were based.

There is no incomplete or unavailable information that is deemed relevant to making a determination regarding reasonably foreseeable, significant adverse impacts or that is essential to a reasoned choice

among alternatives. As noted previously, new information will become available for years. The BOEMRE is a strong advocate of adaptive management. If new, unforeseen information that would require changes in the manner in which BOEMRE regulates and manages oil and gas operations that may result from the proposed lease sale becomes available in the future, appropriate adjustments will be made at that time. However, based on the information known at this time, there is no reason to believe that the conclusions reached in the Multisale EIS and the 2009-2012 Supplemental EIS, which included proposed CPA Lease Sale 216/222, have been altered or changed due to the DWH event.

This chapter has thoroughly examined the existing, credible scientific evidence that is relevant to evaluating the reasonably foreseeable, significant adverse impacts of proposed CPA Lease Sale 216/222 on the human environment. The subject-matter experts that prepared this Supplemental EIS conducted a diligent search for pertinent information, and BOEMRE's evaluation of such impacts is based upon theoretical approaches or research methods generally accepted in the scientific community. All reasonably foreseeable impacts were considered, including impacts that could have catastrophic consequences, even if their probability of occurrence is low. The analysis of impacts contained herein is supported by credible scientific evidence; it is not based on pure conjecture, media reports, or public perception; and it is within the rule of reason.

4.1.1. Alternative A—The Proposed Action

4.1.1.1. Air Quality

The BOEMRE has reexamined the analysis for air quality presented in the Multisale EIS and the 2009-2012 Supplemental EIS based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for air quality presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Emissions of pollutants into the atmosphere from the routine activities associated with the CPA proposed action are projected to have minimal impacts to onshore air quality because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from the coastline, and the emissions are expected to be well within the National Ambient Air Quality Standards (NAAQS). While regulations are in place to reduce the risk of impacts from H_2S and while no H_2S-related deaths have occurred on the OCS, accidents involving high concentrations of H_2S could result in deaths as well as environmental damage. These emissions from routine activities and accidental events associated with the proposed action are not expected to have concentrations that would change onshore air quality classifications. The total impact from all onshore and offshore emissions (such as roads, power generation, and industrial activities) would continue to significantly affect the ozone nonattainment areas in southeast Texas and the parishes near Baton Rouge, Louisiana. The proposed action would have an insignificant contribution to ozone levels in the nonattainment areas and would not interfere with the States' schedule for compliance with the NAAQS.

4.1.1.1.1. Description of the Affected Environment

A detailed description of air quality can be found in Chapter 3.1.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The Clean Air Act (CAA) established the NAAQS. The primary standards are to protect public health, and the secondary standards are set to protect public welfare, such as visibility or to protect vegetation, as shown in **Table 4-1.** The current NAAQS addresses six pollutants: carbon monoxide, lead, nitrogen dioxide (NO_2), particulate matter (PM), ozone (O_3), and sulfur dioxide (SO_2) (**Table 4-1)**. Particulate material is presented as two categories according to size. Coarse particulate matter is between 2.5 μm and 10 μm (PM_{10}), and fine particulate matter is less than 2.5 μm in size ($PM_{2.5}$). Under the CAA,

USEPA is periodically required to review and, as appropriate, modify the criteria based on the latest scientific knowledge. Several revisions to the NAAQS have occurred since the publication of the Multisale EIS, as more is understood about the effects of the pollutants.

Effective December 17, 2006, USEPA revoked the annual PM_{10} standard and revised the 24-hour $PM_{2.5}$ from 65 $\mu g/^3$ to 35 $\mu g/^3$. In early 2008, USEPA promulgated a new, more restrictive NAAQS 8-hour O_3 standard of 0.075 ppm, which has been fully implemented. An additional revision to the 2008 revision of the 8-hour O_3 standard was proposed in January 2010. A value within the range of 0.060 to 0.070 ppm was recommended. As of November 2010, a final O_3 standard has not been issued. With the introduction of a new lower standard, additional Gulf Coast counties/parishes that are presently in attainment may become in nonattainment for ozone. Such an occurrence would likely generate renewed interest in OCS sources to mitigate the OCS contribution to ozone nonattainment. In turn, this would likely require BOEMRE to conduct additional air quality studies to more accurately determine the OCS contribution.

The USEPA also issued revisions to other NAAQS standards during 2010. Effective April 23, 2010, USEPA revised the NO_2 NAAQS standard to a new 1-hour standard of 100 ppb (0.100 ppm). Effective August 23, 2010, USEPA revised the SO_2 NAAQS standard to a 1-hour standard of 75 ppb (0.075 ppm) and revoked the 24-hour and the annual SO_2 standard**.**

In response to the recent DWH event, USEPA and the affected States conducted extensive air quality monitoring along the Gulf Coast. The air monitoring conducted to date has found that the levels of ozone and particulates were at levels well below those that would cause short-term health problems (USEPA, 2010a). The air monitoring also did not find any pollutants at levels expected to cause long-term harm. However, it has been reported in the news that people along the coastal areas felt the effect of the toxic chemicals released from the DWH event and the sprayed dispersant.

Attainment

Air quality depends on multiple variables—the location and quantity of emissions; dispersion rates; distances from receptors; and local meteorology. Meteorological conditions and topography may confine, disperse, or distribute air pollutants in a variety of ways.

The Clean Air Act Amendments of 1990 (CAAA) established classification designations based on regional monitored levels of ambient air quality. These designations impose mandated timetables and other requirements necessary for attaining and maintaining healthful air quality in the U.S. based on the seriousness of the regional air quality problem.

When measured concentrations of regulated pollutants exceed standards established by the NAAQS, an area may be designated as a nonattainment area for a regulated pollutant. The number of exceedances and the concentrations determine the nonattainment classification of an area. The CAAA establishes five classifications of nonattainment status—marginal, moderate, serious, severe, and extreme.

The Federal OCS waters' attainment status is unclassified. The OCS areas are not classified because there is no provision for any classification in the CAA for waters outside of the boundaries of State waters. Only areas within State boundaries are to be classified as either attainment, nonattainment, or unclassifiable.

Operations west of 87.5^o W. longitude fall under BOEMRE jurisdiction for enforcement of the Clean Air Act (42 U.S.C. 7401 et seq.). The OCS waters east of 87.5^o W. longitude are under the jurisdiction of USEPA.

Figure 4-1 presents the air quality status in the Gulf Coast as of April 2011. All air-quality nonattainment areas reported in **Figure 4-1** are for ozone nonattainment. As of May 27, 2008 (effective day), the new 8-hour ozone standard NAAQS of 0.075 ppm has been fully implemented (USEPA, 2011a). As of January 22, 2010, the new 1-hour nitrogen dioxide standard of 100 ppb has been fully implemented.

The attainment or nonattainment status for criteria pollutants (i.e., CO, SO_2, NO_2, PM, and O_3) for the Gulf Coast States adjacent to the CPA are stated below (USEPA, 2011b).

Louisiana is in attainment for CO, SO_2, NO_2, and PM, and nonattainment for O_3. The nonattainment parishes in Louisiana include Ascension, East Baton Rouge, Iberville, Livingston, and West Baton Rouge Parishes (USEPA, 2011b). More recent monitoring data collected in the period 2006-2009 indicated that the Baton Rouge nonattainment area has not had any violations of the 8-hour ozone standard. The State is in the process of submitting the needed information so that USEPA can redesignate the area to attainment

(*Federal Register*, 2010e). A steady decline over the last two decades is a result of deliberate actions to reduce ozone precursor emissions, as well as research and regulatory work done to understand the causes of ozone formation in the area (Louisiana Dept. of Environmental Quality, 2004). The average number of ozone exceedances in the area has declined, as has the number of air-pollution monitors recording exceedances.

The PSD Class I air quality areas, designated under the Clean Air Act, are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for PSD Class I areas are as follows: 2.5 $\mu g/^3$ annual increment for NO_2; 25 $\mu g/^3$ 3-hour increment, 5 $\mu g/^3$ 24-hour increment, and 2 $\mu g/^3$ annual increment for SO_2; and 8 $\mu g/^3$ 24-hour increment and 4 $\mu g/^3$ annual increment for PM_{10}. The CPA includes the Breton National Wildlife Refuge and National Wilderness Area (BNWA) south of Mississippi, which is designated as a PSD Class I area. The FWS has responsibility for protecting wildlife, vegetation, visibility, and other sensitive resources called air-quality-related values in this area. The FWS has expressed concern that the NO_2 and SO_2 increments for the Breton National Wilderness Area have been consumed. The BOEMRE has addressed FWS concerns with scientific study to determine the pollutant increment status at BNWA. The results obtained from this study show that the maximum 3-hour, 24-hour, and annual SO_2 increments were not exceeded within the BNWA, but a portion of the increment was consumed (Wheeler et al., 2008). Likewise, the maximum annual NO_2 increment was not exceeded within the BNWA, but a portion of the increment was consumed. The exact effect of the DWH event on the BNWA is not known. However, it is expected that the effect of the DWH event on the air quality at the BNWA would be small since the air emissions from the DWH are temporary sources.

Jurisdiction

The responsibilities of BOEMRE are described in the OCSLA (43 U.S.C. 1334(a)(8)), which requires the Secretary of the Interior to promulgate and administer regulations that comply with the NAAQS, pursuant to the CAA (42 U.S.C. 7401 et seq.) and to the extent that authorized activities significantly affect the air quality of any State. In 1990, pursuant to Section 328 of the CAAA and following consultation with the Commandant of the USCG and the Secretary of the Department of the Interior, the OCS waters east of 87.5^o W. longitude were transferred to within the jurisdiction of USEPA. Operations west of 87.5^o W longitude in the GOM remain under BOEMRE jurisdiction for enforcement of the NAAQS.

The USEPA promulgated OCS air quality regulations at 40 CFR 55 to implement the statutory objectives. Over the past several years, BOEMRE has leased some blocks that are east of 87.5^o W. longitude. These lessees are working with USEPA to obtain permits for air emissions (USEPA, 2010b).

Emission Inventories

The CAAA requires BOEMRE to coordinate air-pollution control activities with USEPA. Thus, there will be a continuing need for emission inventories and modeling in the future. The following is a summary of new information available since publication of the Multisale EIS and the 2009-2012 Supplemental EIS.

The BOEMRE has completed two air emissions inventory studies for calendar years 2008 (Wilson et al., 2010) and 2005 (Wilson et al., 2007). These studies estimated emissions for all OCS oil and gas production-related sources in the Gulf of Mexico, including nonplatform sources, as well as other non-OCS-related emissions. The inventories included carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), PM_{10}, $PM_{2.5}$, and VOC's, as well as greenhouse gases—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The widespread damage in the Gulf of Mexico caused by Hurricanes Katrina and Rita impacted the inventory results for September through December 2005. Due to the impacts of the hurricanes on OCS facilities in 2005, an updated Gulfwide emissions inventory study was funded for calendar year 2008, and more inventory data have been collected. At present, the 2008 study is finished, but it is only available in draft form. In the summer of 2010, BOEMRE funded another cycle of this air emissions inventory to be conducted during 2011. These emissions inventories

will be used in air quality modeling to determine the potential impacts of offshore sources to onshore areas.

The USEPA implemented the new ozone standard of 75 ppb in 2008. As a result, additional Gulf Coast counties/parishes have become nonattainment for ozone, which would likely generate renewed interest in OCS sources to mitigate the OCS contribution to ozone nonattainment areas. In turn, this would likely require BOEM to conduct additional air quality studies to more accurately determine the OCS contribution.

Greenhouse Gas Reporting

In response to the FY 2008 Consolidated Appropriations Act, USEPA issued 40 CFR 98, which requires reporting of greenhouse gas emissions. On November 8, 2010, Subpart W of the Greenhouse Gas Reporting Rule was finalized. Subpart W requires petroleum and natural gas facilities that emit 25,000 metric tons or more of CO_2 equivalents per year to report emissions from equipment leaks and venting. The USEPA has determined that the activity data (Gulfwide Offshore Activities Data System [GOADS]) that has been collected to fulfill BOEMRE's emissions inventory may be used to comply with Subpart W of the USEPA Greenhouse Gas Reporting Rule. Subpart C of the Greenhouse Gas Reporting Rule requires operators to report greenhouse gas emissions from general stationary fuel combustion sources to USEPA. At this time, BOEMRE's GOAD's activity data may not be used to comply with Subpart C; therefore, affected operators will have to perform some additional efforts in order to comply with Subpart C (USEPA, 2010c).

4.1.1.1.2. Impacts of Routine Events

Background/Introduction

A detailed description of routine events on air quality in the Gulf of Mexico can be found in Chapter 4.2.2.1.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.1.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The following routine activities associated with the CPA proposed action would potentially affect air quality: platform construction and emplacement; platform operations; drilling activities; flaring; seismic-survey and support-vessel operations; pipeline laying and burial operations; evaporation of volatile petroleum hydrocarbons during transfers and fugitive emissions. Supporting materials and discussions are presented in **Chapter 4.1.1.1.1** of this Supplemental EIS, in Chapter 4.1.1.6 and Appendix A-3 of the Multisale EIS, and in Chapter 3.1.1.5.1 of the 2009-2012 Supplemental EIS. The impact analysis is based on four parameters—emission rates, surface winds, atmospheric stability, and the mixing height.

Emissions of certain air pollutants are known to be detrimental to public health and welfare. Some of these pollutants are directly emitted into the air, while others are formed in the atmosphere through chemical reactions. Nitric oxide and nitrogen dioxide constitute nitrogen oxide (NO_x) emissions. Nitrogen oxide, a by-product of all combustion processes, is emitted from sources such as internal combustion engines, natural gas burners, and flares. Nitrogen dioxide is a precursor pollutant involved in photochemical reactions that yield ozone. Nitrogen dioxide is an irritating gas that may increase susceptibility to infection and may constrict the airways of people with respiratory problems. Further, nitrogen dioxide can react with water to form nitric acid, which is harmful to vegetation, animals and materials, as a result of increased acidity in precipitation (i.e., acid rain).

Carbon monoxide (CO) is a by-product of incomplete combustion, primarily contained in engine exhaust. Carbon monoxide is readily absorbed into the body through the lungs, where it reacts with hemoglobin in the blood, reducing the transfer of oxygen within the body. Carbon monoxide particularly affects people with cardiovascular and chronic lung diseases.

Sulfur dioxide (SO_2) may cause constriction of the airways and particularly affects individuals with respiratory diseases. Sulfur dioxide reacts in the atmosphere, principally with water vapor and oxygen, producing sulfuric acid, which along with nitric acid are the major constituents of acid rain. Acid rain can be harmful to animals, vegetation, and materials. The flaring of natural gas containing hydrogen sulfide

(H_2S) and the burning of liquid hydrocarbons containing sulfur (Chapter 4.1.1.9 of the Multisale EIS) result in the formation of SO_2. The amount of SO_2 produced is directly proportional to the sulfur content of the hydrocarbons being flared or burned.

The concentration of the H_2S varies substantially from formation to formation and even varies to some degree within the same reservoir. Natural gas from the Norphlet Formation in the northeastern portion of the CPA, just south of Alabama and Mississippi, tends to range between 40 and 140 ppm on the OCS. Nevertheless, two wells are known to have H_2S concentrations of 1.8 and 2.5 percent (18,000 and 25,000 ppm, respectively) in the OCS. Higher concentrations do occur within the Norphlet Formation farther north under State territorial waters and below land.

Additionally, the area around the Mississippi River Delta is a known sulfur-producing area. The natural gas in deepwater reservoirs has been mainly sweet (i.e., low in sulfur content), but the oil averages between 1 and 4 percent sulfur content by weight. By far, most of the documented production of sour gas (i.e., high sulfur content) lies within 150 km (93 mi) of the Breton National Wilderness Area.

Flaring of gas containing H_2S (sour gas) is of concern because it could significantly impact onshore areas, particularly when considering the short-duration averaging periods (1 and 24 hours) for SO_2. The combustion of liquid hydrocarbon fuel is the primary source of sulfur oxides (SO_x), when considering the annual averaging period; however, impacts from high-rate well cleanup operations can generate significant SO_2 emissions. To prevent inadvertently exceeding established criteria for SO_2 for the 1-hour and 24-hour averaging periods, all incinerating events involving H_2S or liquid hydrocarbons containing sulfur are evaluated individually during the postlease process.

The VOC's are precursor pollutants involved in a complex photochemical reaction with NO_x in the atmosphere to produce ozone. The primary sources of VOC's result from venting and evaporative losses that occur during the processing and transporting of natural gas and petroleum products. A more concentrated source of VOC's is the vents on glycol dehydrator units.

Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. The USEPA groups particle pollution into two categories. "Coarse particles," such as those found near roadways and dusty industries, range in size from 2.5 to 10 μm in diameter. The PM_{10} (particulate matter of 10 μm) can also affect visibility, primarily because of the scattering of light by the particles and, to a lesser extent, light absorption by the particles. This analysis considers mainly total suspended particulate (PM_{10}) matter. "Fine particles," such as those found in smoke and haze, have diameters smaller than 2.5 μm. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries, and automobiles react in the air. In general, particles with a diameter of 2.5 μm are more harmful to people because they pass through the throat and nose and enter the lungs (USEPA, 2010d).

Ozone is a nearly colorless gas with a faint but distinctive odor, somewhat similar to chlorine. It is formed in the troposphere (i.e., lower level of the atmosphere) from complex chemical reactions involving VOC's and NO_x in the presence of sunlight. At ground level, ozone can cause or aggravate respiratory problems, interfere with photosynthesis, damage vegetation, and crack rubber. Children, the elderly, and healthy people who work or exercise strenuously outdoors are particularly sensitive to elevated ozone concentrations.

Emissions of air pollutants would occur during exploration, development, and production activities. The profile of typical emissions for exploratory and development drilling activities (Chapter 4.1.1.6 of the Multisale EIS) shows that emissions of NO_x are the most prevalent pollutant of concern. Emissions during exploration are higher than emissions during development due to power requirements for drilling a deeper hole.

Platform emission rates for the GOM region (Chapter 4.1.1.6 of the Multisale EIS) are provided from the 2008 emission inventory of OCS sources (Wilson et al., 2010). This compilation was based on information from a survey of 3,304 platforms from 103 companies, which represented an 85 percent response rate. Since these responses included all the major oil and gas production facilities, they were deemed representative of the type of emissions to be associated with a platform. The NO_x and VOC's are the primary pollutants of concern since both are considered to be precursors to ozone. Emission factors

for other activities such as support vessels, helicopters, tankers, and loading and transit operations were taken from the OCS emission inventory (Wilson et al., 2010).

Flaring is the venting and/burning of natural gas from a specially designed boom. Flaring systems are also used to vent gas during well testing or during repair/of production equipment. The BOEMRE operating regulations provide for some limited volume, short duration flaring or venting of some natural gas volumes upon approval by BOEMRE. These operations may occur for short periods of time (typically 2-14 days) as part of unloading/operations that are necessary to remove potentially damaging completion fluids from the wellbore, to provide sufficient reservoir data for the operator to evaluate a reservoir and development options, and in emergency situations. Accidents, such as oil spills, blowouts and pipeline ruptures, are another source of emissions related to OCS operations. The potential impacts from these accidental events are discussed in **Chapter 4.1.1.1.3**.

Once pollutants are released into the atmosphere, atmospheric transport and dispersion processes begin circulating the emissions. Transport processes are carried out by the prevailing net wind circulation. During summer, the wind regime in the CPA is predominantly onshore at mean speeds of 3-5 m/sec (6.7-11.2 mph). Average winter winds are predominantly offshore at speeds of 4-8 m/sec (8.9-17.9 mph) (Appendix A.3 of the Multisale EIS).

Dispersion depends on emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed. For emissions within the atmospheric boundary layer, the vertical heat flux, which includes effects from wind speed and atmospheric stability (via air-sea temperature differences), is a good indicator of turbulence available for dispersion (Lyons and Scott, 1990). Heat flux calculations in the CPA (Florida A&M University, 1988) indicate an upward flux year-round, being highest during winter and lowest in summer.

The mixing height is very important because it determines the vertical space available for spreading the pollutants. The mixing height is the height above the surface of the earth through which vigorous vertical mixing occurs. Vertical mixing is most vigorous during unstable conditions and is suppressed during stable conditions resulting in the worst periods of air quality. Although mixing height information throughout the GOM is scarce, measurements near Panama City, Florida (Hsu, 1979), show that the mixing height can vary between 400 and 1,300 m (1,312 and 4,265 ft), with a mean of 900 m (2,953 ft). The mixing height tends to be higher in the afternoon, more so over land than over water. Further, the mixing height tends to be lower in winter, with daily changes smaller than in summer.

Proposed Action Analysis

The OCS emissions in tons per year for the criteria pollutants for the CPA proposed action are indicated in Table 4-25 of the Multisale EIS. The major pollutant emitted is NO_x, while PM_{10} is the least emitted pollutant. Combustion-intensive operations such as platform operations, well drilling, and service-vessel activities contribute mostly NO_x; platform operations are also the major contributors of VOC emissions. Platform construction emissions contribute appreciable amounts of all pollutants over the life of the proposed action. These emissions are temporary in nature and generally occur for a period of 3-4 months. Typical construction emissions result from the derrick barge placing the jacket and various modular components and from various service vessels supporting this operation. The drilling operations contribute considerable amounts of all pollutants. These emissions are temporary in nature and typically occur over a 40-day drilling period. Support activities for OCS activities include crew and supply boats, helicopters, and pipeline vessels; emissions from these sources consist mainly of NO_x and CO. These emissions are directly proportional to the number and type of OCS operations requiring support activities. Most emissions from these support activities occur during transit between the port and the offshore facilities; a smaller percentage of the emissions occur during idling at the platform. Platform and well emissions were calculated using the integration of projected well and platform activities over time.

The total pollutant emissions per year are not uniform. At the beginning of the proposed activities, emissions would be the largest. Emissions peak early on, as development and drilling start relatively quickly, followed by production. After reaching a maximum, emissions would decrease as wells are depleted and abandoned, platforms are removed, and service-vessel trips and other related activities are no longer needed.

The BOEME regulations (30 CFR 250.303) establish 1-hour and 8-hour significance levels for CO. A comparison of the projected emission rate to BOEMRE's exemption level would be used to assess CO impacts. The formula to compute the emission rate in tons/for CO is $3{,}400 \bullet D^{2/3}$; D represents distance in statute miles from the shoreline to the source. This formula is applied to each facility.

The VOC emissions are best addressed as their corresponding ozone impacts, which were studied in the GOM Air Quality Study (GMAQS) (Systems Applications International, et al., 1995). The GMAQS indicated that OCS activities have little impact on ozone exceedance episodes in coastal nonattainment areas, including the Houston/Beaumont, Port Arthur/Lake Charles, and Baton Rouge areas. Total OCS contributions to the exceedance (greater than 120 ppb) episodes studied were less than 2 ppb. In the GMAQS, the model was also run using double emissions from OCS petroleum development activities, and the resulting attributable ozone concentrations, during modeling exceedance episodes, were still small, ranging 2-4 ppb. The activities under the proposed action would not result in a doubling of the emissions, and because the proposed activities are substantially smaller than this worst-case scenario, it is logical to conclude that their impact would be substantially smaller as well (Systems Applications International et al., 1995). Additionally, 30 CFR 250.303(g)(2) requires that, if a facility would significantly impact (defined as exceeding BOEMRE's significance levels) an onshore nonattainment area, then it would have to reduce its impact fully through the application of the best available control technology and possibly through offsets as well. The new 8-hour ozone standard (0.075 ppm) has been fully implemented as of May 27, 2008. It is more stringent than the previous 1-hour standard as well as the old 8-hour standard. In response to the 1997 ozone standard (0.08 ppm), the updated ozone modeling was performed using a preliminary Gulfwide emissions inventory for the year 2000 to examine the O_3 impacts with respect to the new 8-hour ozone standard. Two modeling studies were conducted. One modeling study focused on the coastal areas of Louisiana extending eastward to Florida (Haney et al., 2004). This study showed that the impacts of OCS emissions on onshore O_3 levels were very small, with the maximum contribution of 1 ppb or less at locations where the standard was exceeded. The other modeling effort dealt with O_3 levels in southeast Texas (Yarwood et al., 2004). The results of this study indicated a maximum contribution of 0.2 ppb or less to areas exceeding the standard.

Current industry practice is to transport OCS-produced oil and gas via pipeline whenever feasible. It is estimated that over 99 percent of the gas and oil would be piped to shore terminals. Thus, fugitive emissions associated with tanker and barge loadings and transfer would be small, as would the associated exhaust emissions. Safeguards to ensure minimum emissions from any offloading and loading operations of OCS crude oil production from surface vessels at ports have been adopted by the State of Louisiana (Marine Vapor Recovery Act, 2010, LAC 33:III.2108 [Louisiana Dept. of Environmental Quality, 2010]).

The BOEMRE studied the impacts of offshore emissions using the Offshore and Coastal Dispersion (OCD) Model. Three large areas in the CPA were modeled. The limiting factor on the size of each area was the run time needed to process the number of sources. The three areas modeled were a 150-km (93-mi) radius centered over Breton Island, a 100-km (62-mi) radius centered over the Grand Isle area, and a 241-km (150-mi) radius over the Vermilion area. Receptors were set along the coastline and also a short distance inland in order to capture coastal fumigation. Circular areas were chosen to reduce edge effect. The Breton area was chosen to capture the PSD Class I area. The other two areas were selected to best capture most of the offshore sources and to focus on the highly concentrated areas of development. Ratios between these two sets of total emission rates were developed and applied to the 2008 inventory; this modified inventory was then used as the database for the sources for the OCD modeling. Only the onshore maximum concentrations reported for all of the runs are discussed. The results of the runs are reported in Tables 4-26 and 4-27 of the Multisale EIS. The results are also compared with the federally allowable increases in ambient concentrations as regulated by 30 CFR 250.303 and 40 CFR 52.21.

Tables 4-26 and 4-27 of the Multisale EIS list the highest predicted contributions to onshore pollutant concentrations from OCS activities, as well as the maximum allowable increases over a baseline concentration established under the air quality regulations. While these tables show that the proposed lease sale alone would result in concentration increases that are well within the maximum allowable limits for PSD Class I and Class II areas, a direct comparison between the two sets of figures is not possible. This is because the actual maximum allowable increase depends on the net change in emissions from all other sources in the area, both offshore and onshore, since the date the baseline level was established. Sources that were already in place at the applicable baseline date are included in the establishment of the baseline and corresponding concentration and do not count in the determination of the maximum

allowable increment. The PM_{10} are emitted at a substantially smaller rate than NO_2 and SO_2; hence, impacts from PM_{10} would be expected to be small. Since the proposed action would represent approximately 4-5 percent of OCS activities in the CPA, emissions from activities resulting from the proposed action would be substantially below the maximum allowable limits for a PSD Class II area.

Suspended particulate matter is important because of its potential in degrading the visibility in national wildlife refuges or recreational parks designated as PSD Class I areas. The impact depends on emission rates and particle size. Particle size represents the equivalent diameter (diameter of a sphere) that would have the same settling velocity as the particle. Particle distribution in the atmosphere has been characterized as being largely trimodal (Godish, 1991), with two peaks located at diameters smaller than 2 µm and a third peak with a diameter larger than 2 µm. Particles with diameters of 2 µm or larger settle very close to the source (residence time of approximately ½ day, Lyons and Scott, 1990). For particles smaller than 2 µm, which do not settle fast, wind transport determines their impacts. Projected PM_{10} concentrations are expected to have a low impact on the visibility of PSD Class I areas.

Gaseous and fine particulate matter in the atmosphere can potentially degrade the atmospheric visibility. The visibility degradation is primarily due to the presence of particulates with the size in the range of 1 to 2 microns (micrometers). The sources of these particulates may come from fuel burning and the chemical transformation of the atmospheric constituents. The chemical transformation of NO_2, SO_2, and VOC may produce nitrates, sulfates, and carbonaceous particles. High humidity also may contribute to the visibility impairment in the Gulf coastal areas. Visibility is considered an important resource in the Breton National Wilderness Area, a Federal Class I area. Since future air emission from all sources in the area are expected to be about the same level or less, it is expected that the impact on visibility due to the presence of fine particulates would be minor.

The Breton National Wilderness Area is a Class I air quality area administered by FWS. Under the Clean Air Act, BOEMRE would notify FWS and the National Park Service if emissions from proposed projects may impact the Breton Class I area. Mitigating measures and stricter air emissions monitoring and reporting requirements are required for sources that are located within 100 km (62 mi) of the Breton Class I Area and that exceed emission levels agreed upon by the administering agencies.

Summary and Conclusion

Emissions of pollutants into the atmosphere from the routine activities associated with the CPA proposed action are projected to have minimal impacts to onshore air quality because of the prevailing atmospheric conditions, emission heights, emission rates, and the distance of these emissions from the coastline. As indicated in the GMAQS and other modeling studies, the proposed action would have only a small effect on ozone levels in ozone nonattainment areas and would not interfere with the States' schedule for compliance with the NAAQS. Regulations, monitoring, mitigation, and developing emissions-related technologies would ensure these levels stay within the NAAQS.

4.1.1.1.3. Impacts of Accidental Events

Background/Introduction

A description of impacts of accidental events can be found in Chapter 4.4.1 of the Multisale EIS and an update to include the 181 South Area can be found in Chapter 4.1.1.3 of the 2009-2012 Supplemental EIS.

The accidental release of hydrocarbons related to the CPA proposed action would result in the emission of air pollutants. The OCS accidents would include the release of oil, condensate, or natural gas or chemicals used offshore or pollutants from the burning of these products. The air pollutants include criteria NAAQS pollutants, volatile and semi-volatile organic compounds, hydrogen sulfide, and methane. These pollutants are discussed in **Chapter 4.1.1.1.2** above. If a fire was associated with the accidental event, it would produce a broad array of pollutants, including all NAAQS-regulated primary pollutants, including NO_2, CO, SO_x, VOC, PM_{10}, and $PM_{2.5}$. The discussion below addresses a 15,000-bbl spill. In the spill size category of >10,000 bbl, the average of the largest historical spills is 15,000 bbl and is the average volume of two pipeline spills that occurred (Anderson and LaBelle, 2000).

A catastrophic event is a high-volume, long-duration oil spill or a "spill of national significance." An analysis of the impact of a catastrophic spill is included in **Appendix B**. Many Federal and State agencies

and companies participate in a catastrophic event such as the DWH event. Response-worker air quality onshore and on-water was monitored by the Occupational Safety and Health Administration (OSHA), USCG, and the responsible party to ensure a safe work environment. Coastal community air quality was monitored by USEPA and State environmental agencies. The results from these efforts are available on DWH event websites such as http://www.epa.gov/bpspill/air.html.

Proposed Action Analysis

The accidental release of hydrocarbons or chemicals from the CPA proposed action would cause the emission of air pollutants. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. Accidents, such as oil spills and blowouts, are a source of emissions related to OCS operations. Typical emissions from OCS accidents consist of hydrocarbons; only fires produce a broad array of pollutants, including all NAAQS-regulated primary pollutants. The criteria pollutants considered here are NO_2, CO, SO_x, VOC, PM_{10}, and $PM_{2.5}$.

NAAQS Pollutants

Some of the NAAQS pollutants, the VOC's and NO_x, are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. Human exposure to ground-level ozone exposure causes a variety of health problems including airway irritation, aggravation of asthma, and increased susceptibility to respiratory illnesses. Ozone levels could increase, especially if the oil spill were to occur on a hot, sunny day with sufficient concentrations of NO_x present in the lower atmosphere. An accidental spill would possibly have a temporary localized adverse effect due to NAAQS pollutant concentrations. Due to the distance from shore and an assumed accidental spill size of 15,000 bbl, an oil spill would not affect onshore ozone concentrations.

The VOC emissions from the evaporation of oil spill can contribute to the formation of particulate matter ($PM_{2.5}$). In-situ burning also generates particulate matter. Particulate matter can cause adverse human respiratory effects and can also result in a haze. The $PM_{2.5}$ concentrations in a plume could have the potential to temporarily degrade visibility in any affected PSD Class I areas (i.e., National Wilderness Areas and National Parks) such as the Breton National Wilderness Area in the CPA and other areas where visibility is important.

Hydrocarbons

Oil is a mixture of many different chemical compounds, some of which are hazardous to health. Toxic chemicals can cause headache or eye irritation and some other symptoms. Benzene can cause cancer at high levels and long exposures. The benzene, ethylbenzene, toluene, and xylene (BTEX fraction) of oil is light and volatilizes into air. The BTEX level is commonly measured to provide an indication of the level air quality. During an accidental spill, the levels of BTEX in the immediate area could exceed safe levels. In hazardous conditions, OSHA and USCG regulations require workers to use breathing protection. An accidental spill would possibly result in temporary localized elevated levels of hydrocarbons. Due to the distance to shore and an assumed accidental spill size of 15,000 bbl, an accidental spill would not result in elevated onshore BTEX concentrations. An analysis of the impact of a catastrophic spill, of far greater size, is included in **Appendix B**.

Hydrogen Sulfide (H_2S)

The presence of H_2S within formation fluids occurs sporadically throughout the Gulf of Mexico OCS and may be released during an accident. The concentrations of H_2S found to date are generally greatest in the eastern portion of the CPA. There has been some evidence that petroleum from deep water contain significant amounts of sulfur. The H_2S concentrations in the OCS vary from as low as a fraction of a ppm to as high as 650,000 ppm. Hydrogen sulfide can cause acute symptoms, including headaches, nausea, and breathing problems. During an accidental event, H_2S concentrations could be high enough in the immediate area to be life threatening. The BOEMRE's regulations (30 CFR 250.490(a)(1)) and the clarifying Hydrogen Sulfide NTL (NTL 2009-G31) requires a Contingency Plan, as well as sensors and alarms (30 CFR 250.490(d)) to alert and protect workers from H_2S releases.

In-situ Burning

In-situ burning of a spill results in emissions of NO_2, SO_2, CO, and PM_{10}, and would generate a plume of black smoke. Fingas et al. (1995) describes the results of a monitoring program of a burn experiment at sea. The program involved extensive ambient measurements during two experiments in which approximately 300 bbl of crude oil were burned. It found that during the burn, CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels. Ambient levels of VOC were high within about 100 m (328 ft) of the fire but were significantly lower than those associated with a nonburning spill. Measured concentrations of polycyclic aromatic hydrocarbons (PAH's) were low. It appeared that a major portion of these compounds was consumed in the burn. In measurements taken from the NOAA WP-3D aircraft, lofted plumes from the controlled burns rose above the marine boundary layer of 2,000 ft (610 m) (Ravishankara and Goldman, 2010).

McGrattan et al. (1995) modeled smoke plumes associated with in-situ burning. The results showed that the surface concentrations of particulate matter did not exceed the health criterion of 150 $\mu g/^3$ beyond about 5 km (3 mi) downwind of an in-situ burn. This is quite conservative since this health standard is based on a 24-hour average concentration rather than a 1-hour average concentration. This appears to be supported by field experiments conducted off of Newfoundland and in Alaska. In summary, the impacts from in-situ burning are temporary. Pollutant concentrations would be expected to be within the NAAQS. The air quality impacts from in-situ burning would therefore be minor.

Dioxins and furans are a family of extremely persistent chlorinated compounds that magnify in the food chain. During an in-situ burn, the conditions exist (i.e., incomplete hydrocarbon combustion and the presence of chlorides in seawater) for dioxins and furans to potentially form. Measurements of dioxins and furans during the DWH event in-situ burning were made (Aurell and Gullett, 2010). The estimated levels of dioxins and furans produced by the in-situ burns were similar to those from residential woodstove fires and slightly lower than those from forest fires, according to USEPA researchers (Schaum et al., 2010) and, thus, concerns about bioaccumulation in seafood were alleviated.

Flaring

Flaring may be conducted to manage excess gas during an accidental event such as damage to a pipeline. For the DWH event, a flare that burned both oil and gas was employed. Flaring would result in the release of NO_x emissions from the flare. The SO_2 emissions would be dependent on the sulfur content of the crude oil.

Particulate matter from the flare would also affect visibility. Flaring or burning activities upwind of a PSD Class I area, e.g., the Breton National Wilderness Area in the CPA, could adversely affect air quality through increased SO_2 concentrations and reduced visibility. More information about the DWH event flaring is available in **Appendix B**.

In-situ burning and flaring are temporary efforts to limit environmental impact during an accidental spill. Flaring needs to be approved by the Regional Director. The appropriate agencies will monitor for worker safety. Pollutant concentrations onshore would be expected to be within the NAAQS and not to have onshore impacts.

Dispersants

Dispersants may be applied to break up surface and subsurface oil following an accidental spill. In surface application, aircraft fly over the spill, similar to crop dusting on land, and spray dispersants on the visible oil. Dispersant usage is usually reserved for offshore locations. There is the possibility that the dispersant mist can drift from the site of application to a location where workers or the community are exposed by both skin contact and inhalation. Following the DWH event, USEPA provided the TAGA bus, a mobile laboratory, to perform instantaneous analysis of air in coastal communities. Two ingredients in the *Corexit* dispersant were measured. Very low levels of dispersants were identified. Due to the distance to shore and an assumed accidental spill size of 15,000 bbl, it is unlikely that dispersants would be carried to onshore areas.

Odors

An accidental spill could result in odors (USEPA, 2010e). The low levels of pollutants may cause temporary eye, nose, or throat irritation, nausea, or headaches, but the doses are not thought to be high enough to cause long-term harm (USEPA, 2010e). Due to the distance to shore and an assumed accidental spill size of 15,000 bbl, it is unlikely that applied dispersants would drift to onshore areas.

Summary and Conclusion

Accidental events associated with the CPA proposed action that could impact air quality include spills of oil, natural gas, condensate, and refined hydrocarbons; H_2S release; fire; and NAAQS air pollutants (i.e., SO_x, NO_x, VOC's, CO, PM_{10}, and $PM_{2.5}$). Response activities that could impact air quality include in-situ burning, the use of flares to burn gas and oil, and the use of dispersants applied from aircraft. Measurements taken during an in-situ burning show that a major portion of compounds was consumed in the burn; therefore, pollutant concentrations would be expected to be within the NAAQS. In a recent analysis of air in coastal communities, low levels of dispersants were identified. These response activities are temporary in nature and occur offshore; therefore, there are little expected impacts from these actions to onshore air quality. Accidents involving high concentrations of H_2S could result in deaths as well as environmental damage. Regulations and NTL's are in place to protect workers from H_2S releases. Other emissions of pollutants into the atmosphere from accidental events as a result of the CPA proposed action are not projected to have significant impacts on onshore air quality because of the prevailing atmospheric conditions, emissions height, emission rates, and the distance of these emissions from the coastline. These emissions are not expected to have concentrations that would change onshore air quality classifications.

During the DWH event, a huge number of air samples were collected. Analyses included BETX, PM, H_2S, NAAQS criteria pollutants, and dioxin. According to USEPA, in coastal communities air pollutants from the DWH event were at levels well below those that would cause short-term health problems. The air monitoring conducted to date has not found any pollutants at levels expected to cause long-term harm (USEPA, 2010a). However, serious questions have been raised concerning the effects of the DWH event on public health and the workers, resulting from the releases of particles and toxic chemicals due to evaporation from oil spill, flaring, oil burn, and the applications of dispersants (Rotkin-Ellman et al., 2010). Air quality impacts include the emission of pollutants from the oil and the fire emissions that are hazardous to human health and that can possibly be fatal (**Appendix B**).

Overall, since loss of well-control events and blowouts are rare events and of short duration, potential impacts to air quality are not expected to be significant except in the rare case of a catastrophic event. The summary of vast amounts of data collected and additional studies will provide more information in the future.

Although BOEMRE regulates the air emissions and air quality in the Gulf of Mexico region, at present, BOEMRE does not have an air quality model for the estimate of air concentrations from the distance OCS emission sources. Thus, BOEMRE relies on other government agencies for air quality assessment; their air quality models may not be appropriate for the assessment of air quality from the OCS emission sources.

4.1.1.1.4. Cumulative Impacts

Background/Introduction

An impact analysis for cumulative impacts in the WPA and CPA on air quality can be found in Chapter 4.5.1 of the Multisale EIS and was updated in Chapter 4.1.1.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS. This cumulative analysis summary considers OCS and non-OCS activities that could occur and adversely affect onshore air quality and the Breton National Wilderness Area from OCS sources during the 40-year analysis period.

The activities in the cumulative scenario that could potentially impact onshore air quality include the proposed action and the OCS Program, State oil and gas programs, other major factors influencing

offshore environments, onshore non-OCS activities, accidental releases from oil spills, accidental releases from hydrogen sulfide, natural events (e.g., hurricanes), and a catastrophic oil spill.

The activities for the OCS Program include the drilling of exploration, delineation, and development wells; platform installation; service-vessel trips; flaring; and fugitive emissions. Emissions of pollutants into the atmosphere from the activities associated with the OCS Program are not projected to have significant effects on onshore air quality because of the prevailing atmospheric conditions, emission rates and heights, and the resulting pollutant concentrations. Onshore impacts on air quality from emissions from OCS activities are estimated to be within PSD Class II allowable increments. In an Agency-funded study, the modeling results indicate that the cumulative impacts to the Breton Wilderness Class I Area are well within the PSD Class I allowable increment (Wheeler et al., 2008). The OCS contribution to the air quality problem in the coastal areas is small.

State oil and gas programs onshore, in territorial seas, and in coastal waters also generate emissions that affect onshore air quality. These emissions are regulated by State agencies and/or USEPA. Reductions in emissions have been achieved through the use of low sulfur fuels, catalytic reduction, and other efforts and, as a result, constitute minor impacts to onshore air quality.

Other major factors influencing offshore environments, such as sand borrowing and commercial transportation, also generate emissions that can affect air quality. These emissions are regulated by State agencies and/or USEPA. Reductions have been achieved through the use of low sulfur fuels and catalytic reduction and as a result, constitute minor impacts to onshore air quality.

Other major onshore emission sources from non-OCS activities include power generation, industrial processing, manufacturing, refineries, commercial and home heating, and motor vehicles. The total impact from the combined onshore and offshore emissions would be significant to the ozone nonattainment areas in southeast Texas and the parishes near Baton Rouge, Louisiana.

Portions of the Gulf Coast have ozone levels that exceed the Federal air quality standard. Ozone levels are on a declining trend because of air-pollution control measures that have been implemented by the States. This downward trend is expected to continue as a result of local as well as nationwide air-pollution control efforts. However, more stringent air quality standards have recently been implemented by USEPA, which may result in increasing the number of parishes/counties in the coastal states that are in violation of the Federal ozone standard. There is also a proposal to further decrease the ozone standard. If the ozone standard was lowered, although OCS emissions from the proposed action would not vary, the OCS emissions in those newly designated areas would have an incrementally larger contribution to the onshore ozone levels. Although air quality is improving, the number of areas in nonattainment has increased due to the more stringent standard.

The Gulf Coast has significant visibility impairment from anthropogenic emission sources. Area visibility is expected to improve somewhat as a result of regional and national programs to reduce emissions.

Impacts from oil spills for the cumulative scenario would be similar to those described for the proposed 2007-2012 leasing program. The spill could be crude oil, crude oil with a mixture of natural gas, or refined fuel. Air quality would be affected by the additional response vessel traffic, volatization of components of the oil, and natural gas if released. Impacts from individual spills would be localized and temporary.

The scenario of an accidental release of hydrogen sulfide is described in **Chapter 3.1.1.5.1**. The same safety precautions and regulations described in the proposed action are applicable to the cumulative scenario. That is, a typical safety zone of several kilometers is usually established in an area with the concentration of hydrogen sulfide greater than 20 ppm from the source or a platform. In the event of hydrogen sulfide releases, a Contingency Plan is required.

The effects of hurricanes on the offshore infrastructures are described in **Chapters 3.1.1.5.3 and 3.3.7.2**. Hurricanes mainly cause damage to offshore infrastructures and pipelines, which may result in an oil spill. A hurricane would cause minor effects on the onshore air quality since air emissions in the event of a hurricane are temporary sources. For the cumulative scenario, the emissions from oil-spill and repair activities are expected to be the same as the proposed action and to have minimum effects on the onshore air quality.

The accidental impacts from the DWH event are briefly described in **Chapter 4.1.1.1.3 and Appendix B**. The DWH event may have the potential to cause effects on air quality and public health

and the environment, which may occur from the application of dispersants to an oil spill, in-situ oil burning, evaporation of toxic chemicals from oil spill, and cleanup activities.

These events will release and transport the particulate matter to the onshore environment and increase the ozone concentration or the amount of toxic chemicals in the onshore environment. The onshore residents and cleanup workers may be exposed to toxic chemicals, particulate matter, or ozone, and they may experience short-term or long-term health effects.

Modeling tools for the transport and dispersion of air pollutants such as ozone, carbon monoxide, nitrogen dioxide, and PAH's are required to determine the fate and pollutant concentrations in the environment and subsequently, for the assessment of environmental impacts. It appears that these tools are currently not available for the application to the offshore environment, which is needed to be developed, especially for the long-range transport of air pollutants.

In a catastrophic spill, dispersants may be sprayed to break up the slick. The dispersant mist would temporarily degrade the air quality. Health complaints were received from workers on adjacent rigs following dispersant application during the DWH event.

In a catastrophic spill, oil may be burned to prevent it from entering sensitive habitats. The USEPA released two peer-reviewed reports concerning dioxins emitted during the controlled burns of oil during the DWH event (Aurell and Gullet, 2010; Schaum et al., 2010). Dioxins is a category that describes a group of hundreds of potentially cancer-causing chemicals that can be formed during combustion or burning. The reports found that, while small amounts of dioxins were created by the burns, the levels that workers and residents would have been exposed to were below USEPA's levels of concern.

However, at present, a number of scientists, doctors, and health care experts are concerned with the potential public health effects as a result of the DWH event in the Gulf of Mexico, and they found that the VOC's benzene, a cancer-causing agent, has been found to be above Louisiana's ambient air quality standards.

The effects of the DWH event on public health and the environment can be classified as the short-term and long-term effects. The short-term effects includes watery and irritated eyes, skin itching and redness, coughing, and shortness of breath or wheezing. As yet, little is know about the long-term health effects of direct exposure to oil from the DWH event. Past accidental oil-spill events do not provide guidance for the assessment of the long-term impact of the DWH event on public health.

A survey of large oil-spill events in the past indicates that the long-term effects of an oil spill on human health and the environment are still unknown. Several previous large oil spills are described below.

The large oil-spill incidents include the *Ixtoc I* oil spill in the Bay of Campeche in the Gulf of Mexico on June 3, 1979; *Exxon Valdez* oil spill in Prince William Sound, Alaska, in 1989; the *Prestige* oil spill in the Atlantic Ocean near Spain in 2002; and the DWH event in the Gulf of Mexico in 2010.

The *Ixtoc* oil-spill accident occurred in the Bay of Campeche of the Gulf of Mexico on June 3, 1979. This oil spill became one of the largest oil spills in history at that time (Jernelöv and Linden, 1981). It was estimated that an average of approximately 10,000-30,000 bbl of oil per day were discharged into the Gulf of Mexico. It was finally capped on March 23, 1980. Ocean currents carried the oil, which reached as far as the Texas coastline. There is no study of the long-term impact of air quality from this oil spill on the human health.

The DWH event occurred in 2010. To assess the effects of the DWH event on human health and the environment, the Institute of Medicine held a workshop, "Assessing the Human Health Effects of the Gulf of Mexico Oil Spill," in New Orleans, Louisiana, on June 22-23, 2010. It was reported that people in the coastal areas show the stresses and strains of living with the effects of the spill on their livelihood and their way of life (McCoy and Salerno, 2010). Due to the volatile chemicals that evaporated from the oil spill into the atmosphere, people in the coastal areas have been experiencing sickness, fever, coughing, and lethargy. Some of these very dangerous compounds can remain in the air for a long period of time; therefore, no one can say with certainty that people will not have long-term effects from the DWH event.

In summary, there are few studies of the long-term air quality related health effects on humans in the assessments of historic oil spills. Although there are minimal studies, some lessons can be learned from the 1991 Kuwaiti oil-field fires and the effects of oil burning to the DWH event. In the Kuwaiti event, 600 oil wells were set in flame. These burnings produced a composite smoke plume of gaseous constituents (e.g., NO_x, SO_x, and CO_2, etc.), acid aerosols, VOC's, metal compounds, PAH's, and particulate matter. Military personnel deployed to the Persian Gulf War have reported a variety of

symptoms attributed to their exposures, including asthma and bronchitis (Lange et al., 2002). In addition, Lange et al. (2002) did not find that exposures to oil fire smoke caused respiratory symptoms among veterans.

Summary and Conclusion

Emissions of pollutants into the atmosphere from the activities associated with the OCS Program are not projected to have significant effects on onshore air quality because of the prevailing atmospheric conditions, emission rates and mixing heights, and the resulting pollutant concentrations. Reductions in emissions have been achieved through the use of low sulfur fuels, catalytic reduction, and other efforts, and as a result, constitute minor impacts to onshore air quality. Onshore impacts on air quality from emissions from OCS activities are estimated to be within PSD Class II allowable increments. The modeling results indicate that the cumulative impacts to the Breton Wilderness Class I Area are well within the PSD Class I allowable increment (Wheeler et al., 2008).

The Gulf Coast States' ozone levels are declining because of air-pollution control measures that they have implemented. This downward trend is expected to continue as a result of local as well as nationwide air-pollution control efforts. The Gulf Coast has significant visibility impairment from anthropogenic emission sources. Area visibility is expected to improve somewhat as a result of regional and national programs to reduce emissions.

The incremental contribution of the proposed action (as analyzed in Chapter 4.2.2.1.1 of the Multisale EIS) to the cumulative impacts is not significant and is not expected to alter onshore air quality classifications because of the prevailing atmospheric conditions, emission rates and mixing heights, and the resulting pollutant concentrations. Portions of the Gulf Coast onshore areas have ozone levels that exceed the Federal air quality standard, but the incremental contribution from the proposed action is very small. The cumulative contribution to visibility impairment from the proposed action is also expected to remain very small. Area visibility is expected to improve somewhat as a result of regional and national programs to reduce emissions. The proposed action would have an insignificant effect on ozone levels in ozone nonattainment areas and would not interfere with the States' schedule for compliance with the NAAQS. More stringent air quality standards have recently been implemented by USEPA; these standards may result in increasing the number of parishes/counties in the coastal states that will be in violation of the Federal air quality standards, but they would also increase air quality regulations.

There are few studies on the long-term impact of air quality on human health and the environment in the history of oil spills. Each incident is different and exposure factors vary. Therefore, the long-term effects on human health and the environment are still unknown.

4.1.1.2. Water Quality

For the purposes of this Supplemental EIS, water quality is the ability of a waterbody to maintain the ecosystems it supports or influences. In the case of coastal and marine environments, the quality of the water is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Besides the natural inputs, human activity can contribute to diminished water quality through discharges, run-off, dumping, air emissions, burning, and spills. Also, mixing or circulation of the water can either improve the water through flushing or be the source of factors contributing to the decline of water quality.

Evaluation of water quality is done by the measurement of factors that are considered important to the health of an ecosystem. The primary factors influencing coastal and marine environments are temperature, salinity, dissolved oxygen, nutrients, potential of hydrogen (pH), oxidation reduction potential (Eh), pathogens, and turbidity or suspended load. Trace constituents such as metals and organic compounds can affect water quality. The water quality and sediment quality may be closely linked. Contaminants, which are associated with the suspended load, may ultimately reside in the sediments rather than the water column.

The region under consideration is divided into coastal and offshore waters for the following discussion. Coastal waters, as defined by BOEMRE, include all the bays and estuaries from the Rio Grande River to Florida Bay (**Figure 4-2**). Offshore waters, as defined in this Supplemental EIS, include both State offshore water and Federal OCS waters, which includes everything outside any barrier islands to the Exclusive Economic Zone. The inland extent is defined by the Coastal Zone Management Act.

The BOEMRE has reexamined the analysis for water quality presented in the Multisale EIS and the 2009-2012 Supplemental EIS (addition of 181 South Area), based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for water quality presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Impacts from routine activities associated with the proposed action would be minimal if all existing regulatory requirements are met. Coastal water impacts associated with routine activities include increases in turbidity resulting from pipeline installation and navigation canal maintenance, discharges of bilge and ballast water from support vessels, and run-off from shore-based facilities. Offshore water impacts associated with routine activities result from the discharge of drilling muds and cuttings, produced water, residual chemicals used during workovers, structure installation and removal, and pipeline placement. The discharge of drilling muds and cuttings causes temporary increased turbidity and changes in sediment composition. The discharge of produced water results in increased concentrations of some metals, hydrocarbons, and dissolved solids within an area of about 100 m (328 ft) adjacent to the point of discharge. Structure installation and removal and pipeline placement disturbs the sediments and causes increased turbidity. In addition, offshore water impacts result from supply and service-vessel bilge and ballast water discharges.

Small spills (<1,000 bbl) are not expected to significantly impact water quality in coastal or offshore waters. Large spills (≥1,000 bbl), however, could impact water quality in coastal waters. Accidental chemical spills, release of SBF, and blowouts would have temporary localized impacts on water quality.

The activity associated with the proposed action would contribute a small percentage of the existing and future OCS energy industry. The specific discharges, drill muds, cuttings and produced water, and accidents resulting in spills would occur in proportion to production and, therefore, could add a small increase to the anticipated impacts. Furthermore, the vessel traffic and related discharges associated with the proposed action are a fraction of the ongoing commercial shipping and military activity in the Gulf. The impacts of discharges, sediment disturbances, and accidental releases are a small percentage of the overall activity and the overall impacts to coastal and offshore waters.

4.1.1.2.1. Coastal Waters

4.1.1.2.1.1. Description of the Affected Environment

A detailed description of coastal water quality can be found in Chapter 3.1.2.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The Gulf of Mexico is the ninth largest waterbody in the world (USDOC, NOAA, 2008a). The description of the physical oceanography of the Gulf of Mexico is described in Appendix A.2 of the Multisale EIS. The United States portion of the Gulf of Mexico region follows the coastline of five states from the southern tip of Texas moving eastward through Louisiana, Mississippi, Alabama, and ending in the Florida Keys (**Figure 4-2**). The combined coastline of these states totals over 47,000 mi (75,639 km) (when including the shores of all barrier islands, wetlands, inland bays, and inland bodies of water) (USDOC, NOAA, 2008a). The Gulf's coastal areas contain half the wetlands in the United States (USDOC, NOAA, 2008a). Wetlands are discussed in further detail in **Chapter 4.1.1.4**. According to USEPA (2008a), the Gulf Coast coastal area comprises over 750 bays, estuaries, and sub-estuary systems that are associated with larger estuaries. Gulf Coast estuaries and wetlands provide important spawning, nursery, and feeding areas for a wide array of fish wildlife as well as being the home for a wide range of indigenous flora and fauna (USEPA, 2008a). The coastal waters of the Gulf Coast are an extremely productive natural system (USEPA, 2008a), which is also important to the Gulf Coast economy as the major commercial fishing ports in the region yield over 1.2 billion pounds of seafood on an annual basis

(USDOC, NOAA, 2008a). The natural resources of the Gulf of Mexico are also important for tourism and recreation.

Over 150 rivers empty out of North America into the Gulf of Mexico (Gore, 1992, p. 127). The river deltas emptying into the Gulf bring freshwater and sediment into coastal waters (Gore, 1992, pp. 127-131), which affect the water quality of these waters. Rivers carry excess nutrients (e.g., nitrogen and phosphorus), as well as other possible inputs such as contaminants from industrial wastewater discharge, downstream; and this effect is cumulative as the river reaches an estuary (Gore, 1992, pp. 280 and 291). Overenrichment of nutrients may lead to eutrophication that can eventually cause algal blooms and fish kills (Gore, 1992, p. 280) (see below for more information on nutrient enrichment and its effects; also see the wetlands and seagrasses discussions in **Chapters 4.1.1.4 and 4.1.1.5**, respectively). The emptying of rivers into the GOM is part of the hydrologic cycle or water cycle (USDOI, GS, 2010a); understanding this cycle not only explains the movement of water on Earth but also how water quality might be affected by both natural and anthropogenic sources. The water cycle may introduce chemical and physical factors that alter the condition of the natural water, such as the addition of waterborne pollutants, or the addition of warmer water, into the GOM through waterbodies emptying into the GOM, runoff, groundwater discharge, or precipitation. Water quality in coastal waters of the northern Gulf of Mexico is highly influenced by season. Seasonality influences salinity and dissolved oxygen; nutrient content; temperature; pH and Eh; pathogens; turbidity; metals; and organic compounds. Salinity in open water near the coast may vary between 29 and 32 practical salinity units (psu) during fall and winter, but it may decline to 20 psu during spring and summer due to increased runoff (USDOI, MMS, 2000). Oxygen and nutrient concentrations also vary seasonally.

The priority water quality issues identified by the Gulf of Mexico Alliance are (1) reducing risk of exposure to disease-causing pathogens, (2) minimizing occurrence and effects of harmful algal blooms, (3) identifying sources of mercury in Gulf seafood, and (4) improving the monitoring of Gulf water resources (Gulf of Mexico Alliance, 2009a). In addition to water quality itself, nutrients and nutrient impacts are also a regional priority issue for the organization (Gulf of Mexico Alliance, 2009b).

The leading source of contaminants that impair coastal water quality is urban runoff. Urban runoff can include suspended solids, heavy metals and pesticides, oil and grease, and nutrients. Urban runoff increases with population growth, and the Gulf Coast region has experienced a 103 percent population growth since 1970 (USDOC, NOAA, 2008a). Other pollutant source categories include (1) agricultural runoff, (2) municipal point sources, (3) industrial sources, (4) hydromodification (e.g., dredging), and (5) vessel sources (e.g., shipping, fishing, and recreational boating).

The National Research Council (NRC, 2003, Table I-4, p. 237) estimated that, on average, approximately 26,324 bbl of oil per year entered Gulf waters from petrochemical and oil refinery industries in Louisiana and Texas. Further, NRC (2003) calculated an estimate for oil and grease loads from all land-based sources per unit of urban land area for rivers entering the sea. Based on the size of its watershed, the Mississippi River introduced approximately 3,680,938 bbl of oil and grease per year from land-based sources (NRC, 2003, Table I-9, p. 242) into the waters of the Gulf of Mexico.

The zone of hypoxia on the Louisiana-Texas shelf occurs seasonally and is affected by the timing of the Mississippi and Atchafalaya Rivers' discharges carrying nutrients to the surface waters. The hypoxic conditions last until local wind-driven circulation mixes the water again. The 2010 GOM dead zone covered 20,000 km^2 (7,722 mi^2) (LUMCON, 2010a). The 2010 dead zone was reported to be one of the largest ever. The area reported in 2009 measured 8,000 km^2 (3,000 mi^2) (LUMCON, 2009), while the area reported in 2008 measured 20,720 km^2 (8,000 mi^2) (LUMCON, 2008).

Separate zones of hypoxia have been discovered 5-15 mi (8-24 km) off the coast of Texas and are likely the result of freshwater inputs generated in Texas and summer upwelling. In 2007 a Texas-created dead zone was discovered and attributed to excessive rainfall and runoff into the Brazos River (LUMCON, 2010b).

Since the marine environment is a dynamic system, sediment quality and water quality can affect each other. For example, a contaminant may react with the mineral particles in the sediment and be removed from the water column (e.g., adsorption). Thus, under appropriate conditions, sediments can serve as sinks for contaminants such as metals, nutrients, or organic compounds. However, if sediments are (re)suspended (e.g., due to dredging or a storm event), the resuspension can lead to a temporary redox flux, including a localized and temporal release of any formally sorbed metals as well as nutrient recycling (Caetano et al., 2003; Fanning et al., 1982).

The overall coastal condition of the Gulf Coast was evaluated from 2001 to 2002 by USEPA and was rated as fair to poor (USEPA, 2008a). Specifically, water quality was rated as fair while sediment quality and the coastal habit index, a rating of wetlands habitat loss, both of which affect water quality, were rated as poor. The USEPA also conducted similar evaluations from 1990 to 1996 (USEPA, 2001) and again from 1997 to 2000 (USEPA, 2005). Water quality was poor overall in the first Coastal Condition Report, but it increased to fair overall in the latter reports. Conversely, sediment quality was generally fair in the first two reports and decreased to poor in the last report. The Barataria/Terrebonne Estuary, near Port Fourchon, which is a common service base, was ranked fair in terms of water quality (USEPA, 2007b) and was assessed as having moderately high eutrophic conditions by NOAA (Bricker et al., 2007). The Galveston Bay estuary system was ranked poor in terms of water quality and fair to poor in terms of sediment quality (USEPA, 2007b); Galveston Bay was individually characterized as having moderately low eutrophic conditions (Bricker et al., 2007). The estuarine area of the Coastal Bend Bays, which includes Corpus Christi Bay, was ranked fair in terms of water quality and poor in terms of sediment quality (USEPA, 2007b), while Corpus Christi Bay alone was characterized as moderately eutrophic (Bricker et al., 2007).

The NOAA examined additional Gulf Coast estuary systems near the CPA and, of those with sufficient data, the Mississippi/Atchafalaya Plume and Perdido Bay had high overall eutrophic conditions, Barataria Bay had moderate high overall eutrophic conditions, Breton/Chandeleur Sound and Lake Pontchartrain were ranked as having moderate overall eutrophic conditions, the Mississippi River had moderately low overall eutrophic conditions, and Mississippi Sound and Lake Borgne had overall low eutrophic conditions (Bricker et al., 2007).

The condition of the Gulf Coast was altered by the DWH event and associated oil spill. It is currently impossible to estimate precisely the long-term impacts that the spill from the DWH event will have on coastal water quality. Various monitoring efforts and environmental studies have already begun. At the time this Supplemental EIS was prepared, the following sources were used for general information concerning the DWH event:

- BP website on the DWH event (http://www.bp.com/sectiongenericarticle800.do?categoryId=9036575&contentId=7067541);
- Restore the Gulf website on the DWH response (http://www.data.gov/restorethegulf/);
- USEPA website on response to the BP spill in the Gulf of Mexico (http://www.epa.gov/bpspill/epa.html);
- National Science Foundation website on rapid response grants to fund DWH research (http://nsf.gov/awardsearch/progSearch.do?SearchType=progSearch&page=2&QueryText=&ProgOrganization=&ProgOfficer=&ProgEleCode=&BooleanElement=false&ProgRefCode=5987&BooleanRef=false&ProgProgram=&ProgFoaCode=&Restriction=2&Search=Search#results);
- Sea Grant website on DWH oil-spill research and monitoring activities database (http://gulfseagrant.tamu.edu/oilspill/database.htm); and
- Joint Analysis Group review of R/V *Brooks McCall* data to examine subsurface oil (http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf).

More time is needed to fully assess the impacts of the DWH event. Although response efforts decreased the fraction of oil remaining in Gulf waters and reduced the amount of oil contacting the coastline, significant amounts of oil remain (RestoreTheGulf.gov, 2010a).

Coastal water quality will not only be impacted by the oil, gas, and their respective components, but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification

(e.g., dredging, berm building, etc.) and the addition of dispersants and methanol to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree. Fortunately, over time, natural processes can physically, chemically, and biologically degrade oil (NRC, 2003). The physical processes involved include evaporation, emulsification, and dissolution; the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation).

The oil that entered the Gulf of Mexico from the DWH event is a South Louisiana sweet crude oil (i.e., it is low in sulfur) (USDOC, NOAA, 2010b). The oil is fairly high in alkanes (organic compounds containing only carbon and hydrogen and single bonds; sometimes called paraffin or aliphatic compounds) (USDOC, NOAA, 2010b). Because alkanes are simple hydrocarbons, these oils are likely to undergo biodegradation more easily (USDOC, NOAA, 2010b). Weathering of crude can occur within the first 24-48 hours with up to a 40 percent weight loss within 7 days (English, 2010). Also, this oil is less toxic than other crude oils in general because this oil is lower in PAH's than many crude oils.

The DWH event released natural gas into the water column in addition to oil. Methane is the primary component of natural gas (NaturalGas.org, 2010b). Limited research is available for the biogeochemistry of hydrocarbon gases in the marine environment (Patin, 1999, p 233). Methane may stay in the marine environment for long periods of time (Patin, 1999, p. 237) as methane is highly soluble in seawater at the high pressures and cold temperatures found in deepwater environments (NRC, 2003, p. 108); however, methane diffusing through the water column would likely be oxidized in the aerobic zone and would rarely reach the air-water interface (Mechalas, 1974, p. 23). Unfortunately, little is known about methane toxicity in the marine environment, but there is concern as to how methane in the water column might affect fish (**Chapter 4.1.1.16**).

Surface water samples collected along the Gulf Coast in Florida and Alabama by USEPA on June 28 and 29, 2010, found that nickel exceeded acute aquatic life benchmarks in one sample and chronic aquatic life benchmarks in two other samples, which could cause risk to aquatic life (USEPA, 2010f). The USEPA also collected coastal surface water samples on May 21-June 29, 2010, along the coast of Louisiana; the samples were analyzed for two chemicals associated with dispersants, but neither chemical was detected. Surface water samples collected on September 11, 2010, by USEPA found two samples that exceeded chronic aquatic benchmarks for nickel, and one sample exceeded acute and chronic aquatic benchmarks for oil-related compounds. Fortunately, none of the samples exceeded human health benchmarks (USEPA, 2010f). Gulf Coast sediment samples were also collected on June 29 and 30, 2010, but they did not reveal elevated levels of chemicals usually found in oil (USEPA, 2010g). Sediment samples taken as of July 9, 2010, indicated that there may be risks to aquatic life from sediment pollutants at some of USEPA's sampling locations. The USEPA noted that, "These levels have a higher potential for serious impacts to sediment-dwelling organisms and are classified as unhealthy. It is unknown whether the sediment contamination resulted from the BP spill or was already present." In addition, samples collected on August 28 and September 9 and 10, 2010, along the Gulf Coast did not detect dispersant components above reporting limits. Coastal sediment samples collected on September 14 and 15, 2010, found one sample that exceeded the chronic aquatic benchmark for oil-related compounds, while sediment samples collected on September 9-10 and 14-16, 2010, did not detect dispersant chemicals at levels above reporting limits (USEPA, 2010g). More data should evolve over time and eventually data is likely to be placed into context through various reports or papers, which will hopefully provide data on background levels of any contaminants of concern before the spill.

One standard tool used in response to spilled oil on water is dispersants. The purpose of chemical dispersants is to facilitate the movement of oil into the water column in order to encourage weathering and biological breakdown of the oil (i.e., biodegradation) (NRC, 2005; Australian Maritime Safety Authority, 2010). If the oil moves into the water column and is not on the surface of the water, it is less likely to reach sensitive shore areas (USEPA, 2010h). Since sea birds are often on the surface of the water or in shore areas, dispersants are also considered to be very effective in reducing the exposure of sea birds to oil (Australian Maritime Safety Authority, 2010). In addition to dispersion being enhanced by artificial processes, oil may also be dispersed from natural processes. For instance, microbial metabolism of crude oil results in the dispersion of oil (Bartha and Atlas, 1983). Oil dispersion, as a spill-response strategy, has both positive and negative effects. The positive effect is that the oil, once dispersed, is more available to be degraded. The negative effect is that the oil, once dispersed, is more available to microorganisms that temporarily increases the toxicity (Bartha and Atlas, 1983). The toxicity

of dispersed oil in the environment will depend on many factors, including the effectiveness of the dispersion, temperature, salinity, the degree of weathering, type of dispersant, and degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, 2010).

Corexit 9500 and 9527 were used in response to the DWH event and resulting spill (USEPA, 2010h). The components of these dispersants are identical with the exception of the base solvent; Corexit 9527 has an organic solvent as a base (McDonald et al. 1984; USEPA, 2010h). Dispersants used in the 1960's were quite toxic, but more recently developed dispersants such as Corexit are considerably less toxic (Doe and Wells, 1978; Leahy and Colwell, 1990). Lindstrom and Braddock (2002) found that environmental use of Corexit 9500 could result in either increases or decreases in the toxicity of residual oil through selective microbial mineralization of hydrocarbons. In fact, reviews of studies have found that the general effectiveness of dispersants in enhancing biodegradation of crude oil and individual hydrocarbons is highly variable and depends on several factors, including the chemical formulation of the dispersant, its concentration, and the dispersant/oil application ratio (Boehm, 1983). However, there was evidence that the dispersants worked in the case of the DWH event (USDOC, NOAA, 2010c; USEPA, 2010h). Corexit 9527 has been shown to greatly increase volatile liquid hydrocarbons incorporation into water, as well as to accelerate the process in experiments compared with observations where no dispersant was used (McDonald et al. 1984). In fact, dispersants used during the DEH event incident has been noted to reduce the volatile organic compounds that can be a workplace issue for response workers on ships near the site (White House Press Briefing, 2010). Since the amount of dispersants used for the spill resulting from the DWH event is unprecedented and since this is the first time dispersants have been applied in such quantities on the surface in deep waters, and at the depth of the well itself, continual monitoring and evaluation of their use is imperative (White House Press Briefing, 2010).

As a result of the use of subsea dispersants, clouds or plumes of dispersed oil may occur near the blowout site far from coastal waters. Reports thus far from researchers deployed after the DWH event and resulting spill have found such plumes and have shown that the concentrations of these clouds drop to undetectable levels within a few miles (USDOC, NOAA, 2010c). Dissolved oxygen levels are a concern with any release of a carbon source, such as oil and natural gas, and became a particular concern during the DWH event since dispersants were applied at the wellhead for the first time. Thus, USEPA required monitoring protocols in order to use subsea dispersants (USDOC, NOAA, 2010d). In areas where plumes of dispersed oil were previously found, dissolved oxygen levels decreased by about 20 percent from long-term average values in the GOM; however, scientists reported that these levels have stabilized and are not low enough to be considered hypoxic (USDOC, NOAA, 2010e). The drop in oxygen, which has not continued over time, has been attributed to microbial degradation of the oil. Initially released studies indicate that bacteria are degrading hydrocarbons from both gas and oil, but the degradation rates reported in the studies varied considerably (Camilli et al., 2010, Hazen et al., 2010, Valentine et al., 2010). Over time, as the oil continues to be degraded and diffused, hypoxia becomes less of a concern. In fact, the 2010 hypoxic zone could not be linked to the DWH event in either a positive or a negative manner (LUMCON, 2010a).

During the DWH event, one of the earlier attempts to stop the oil from leaking from the well was a procedure called a "top kill" (RestoreTheGulf.gov, 2010b). The top kill involved using water-based drilling muds, which are heavy due to the mineral component barite, in order to stop flow from the well. This procedure was not successful, but during the procedure, 29,712 bbl of water-based mud were used (Boland, personal communication, 2010). Much of this mud ended up on the seafloor. The primary general components of water-based mud (also referred to as water-based drilling fluids) are fresh or saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and water-soluble polymers (USDOI, BOEMRE, 2010h). Water-based drilling mud may be discharged to the ocean under normal operations, but those discharges are regulated by USEPA (USDOI, BOEMRE, 2010h). The BOEMRE research has shown that drilling mud discharges do not move very far, even when discharged at the surface (CSA, 2006a). Since the muds were discharged in deep water, it is not expected that coastal waters and sediments will suffer significant adverse effects.

4.1.1.2.1.2. Impacts of Routine Events

Background/Introduction

A detailed description of routine impacts on coastal water quality can be found in Chapter 4.2.1.1.2.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.1.2 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

The routine activities associated with the CPA proposed action that would impact water quality include the following:

- discharges during drilling of exploration and development wells;
- structure installation and removal;
- discharges during production;
- installation of pipelines;
- workovers of wells,
- maintenance dredging of existing navigational canals;
- service vessel discharges; and
- nonpoint-source runoff.

The scenario information related to the CPA proposed action is presented in **Table 3-2**.

Sediment disturbance and turbidity may result from nearshore pipeline installation or maintenance dredging. The installation of pipelines can increase the local total suspended solids in the water. The adverse effect on water quality would be temporary and localized. Chapter 4.1.2.1.7 of the Multisale EIS notes that COE and State permits would require these turbidity impacts to be mitigated through the use of turbidity screens and other turbidity reduction or confinement equipment. No new navigation channels are expected to be dredged as a result of the CPA proposed action, but the CPA proposed action would contribute to maintenance dredging of existing navigation canals. Maintenance dredging would temporarily increase turbidity levels in the vicinity of the dredging and disposal of materials.

In coastal waters, the water quality would be impacted by the discharges from the service vessels in port. Service-vessel round trips projected for the CPA proposed action are 137,000-220,000 trips over the 40-year life of the proposed action (**Table 3-2**). Based on current service-base usage, it is assumed the majority of these trips would occur in Louisiana's coastal waters. The types of discharges and regulations are discussed in Chapters 4.1.1.4.8 and 4.1.2.2.2 of the Multisale EIS. Most discharges are treated or otherwise managed prior to release. In coastal waters, bilge and ballast water may be discharged with an oil content of 15 ppm or less (33 CFR 151.10). The discharges would affect the water quality locally. However, regulations are becoming more stringent. The USCG Ballast Water Management Program became mandatory for some vessels in 2004 (33 CFR 151 Subparts C and D) (U.S. Dept. of Homeland Security, CG, 2010b). The goal of the program was designed to prevent the introduction on nonindigenous (invasive) species that would affect local water quality. Furthermore, USCG published the Ballast Water Discharge Standard Notice of Proposed Rulemaking in the *Federal Register* on August 28, 2009. Additionally, the final Vessel General Permit, issued by USEPA, became effective on December 19, 2008. This permit is in addition to already existing NPDES permit requirements and now increases the NPDES regulations so that discharges incidental to the normal operation of vessels operating as a means of transportation are no longer excluded unless exempted from NPDES permitting by Congressional legislation (USEPA, 2008b).

Up to one new gas processing plant is projected as a result of the CPA proposed action. In addition, the CPA proposed action would contribute to the use of existing onshore facilities in Louisiana, Mississippi, Alabama, and possibly Texas. These supporting onshore facilities would discharge into local wastewater treatment plants and waterways during routine operations. The types of onshore facilities were discussed in Chapter 4.1.2.2.1 of the Multisale EIS. All point-source discharges are regulated by USEPA, the agency responsible for coastal water quality, or the USEPA-authorized State agency. The USEPA's NPDES storm-water effluent limitation guidelines control storm-water discharges from support facilities. Indirect impacts could occur from nonpoint-source runoff, such as rainfall, which has drained from infrastructure such as a public road and parking lot, and may contribute hydrocarbons, trace-metal pollutants, and suspended sediments. These indirect impacts would be minimal, as long as existing regulations are followed, and difficult to discern from other sources.

Summary and Conclusion

The primary impacting sources to water quality in coastal waters are point-source and storm-water discharges from support facilities, vessel discharges, and nonpoint-source runoff. These activities are not only highly regulated but also localized and temporary in nature. The impacts to coastal water quality from routine activities associated with the CPA proposed action should be minimal as long as all existing regulatory requirements are met.

4.1.1.2.1.3. Impacts of Accidental Events

Background/Introduction

A detailed description of accidental events on coastal water quality can be found in Chapter 4.4.2.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.1.3 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Accidental events associated with the CPA proposed action that could impact coastal water quality include spills of oil and refined hydrocarbons, releases of natural gas, spills of chemicals or drilling fluids, and loss of well control, collisions, or other malfunctions that would result in such spills. **Chapter 3.2** discusses the accidental events that could result from the impact-producing factors and scenario, with particular attention given to the risk of oil spills, response to such oil spills, loss of well control, pipeline failures, vessel collisions, and chemical and drilling fluid spills. A brief summary is presented here. The impacts of rare, catastrophic spills are discussed in **Appendix B**. A catastrophic event would not be expected to occur in coastal waters, but a catastrophic spill in offshore waters could affect coastal waters.

Proposed Action Analysis

Oil Spills and Natural Gas and Condensate Releases

Water quality is altered and degraded by oil spills through the increase of petroleum hydrocarbons and their various transformation/degradation products in the water. The extent of impact from a spill depends on the behavior and fate of oil in the water column (e.g., the movement of oil and the rate and nature of weathering), which, in turn, depends on oceanographic and meteorological conditions at the time (Appendix A.2 and A.3 of the Multisale EIS). Crude oils are not a single chemical, but instead are complex mixtures with varied compositions. The various fractions within the crude behave differently in water. Thus, the behavior of the oil and the risk that the oil poses to natural resources depends on the composition of the specific oil encountered (Michel, 1992). Generally, oils can be divided into three groups of compounds: (1) light-weight; (2) medium-weight; and (3) heavy-weight components. **Chapter 3.2.1** further characterizes the components of oil and discusses oil spills. Chapter 4.3.1 of the Multisale EIS also discusses oil spills in further detail, with Chapter 4.3.1.4 of the Multisale EIS describing the characteristics of OCS oil. Generally, the lighter ends of the oil are more water soluble and would contribute to acute toxicity. As the spill weathers, the aromatic components at the water's surface are

more likely to exit the water. The heavier fractions are less water soluble and would partition to organic matter. This fraction is more likely to persist in sediments and would contribute to longer-term impacts.

In addition to oil, natural gas may also be explored for or produced in the GOM. Wells and sidetracks may produce a mixture of both oil and natural gas. Condensate is a liquid hydrocarbon phase that generally occurs in association with natural gas. The quality and quantity of components in natural gas vary widely by the field, reservoir, or location from which the natural gas is produced. Although there is not a "typical" makeup of natural gas, it is primarily composed of methane (NaturalGas.org, 2010b). Thus, if natural gas were to leak into the environment, methane may be released to the environment. Methane is a carbon source, such as oil, and its introduction into the marine environment could result in lowering dissolved oxygen levels due to microbial degradation. Unfortunately, little is known about the toxicity of natural gas and its components in the marine environment, but there is concern as to how methane in the water column might affect fish (**Chapter 4.1.1.16**).

The National Academy of Sciences (NRC, 2003), Patin (1999), and Boesch and Rabalais (1987) have reviewed the fate and effects of spilled oil and, to a lesser degree, natural gas releases. Chapter 4.3.1.7 of the Multisale EIS presents the risk of coastal spills associated with the proposed action, and **Chapter 3.2.1.3** of this Supplemental EIS supplements and updates that information. Spills in coastal waters could occur at storage or processing facilities supporting the OCS oil and gas industry or from the transportation of OCS-produced oil through State offshore waters and along navigation channels, rivers, and through coastal bays. For coastal spills, two additional factors that must be considered are the shallowness of the area the spill is in and the proximity to shore. Spills in coastal waters are more likely to be in shallow waters than offshore spills. Spills near the shore are less likely to be diluted since the volume of water in shallow waters is less than in deep waters. Furthermore, spills are more likely to contact land as there is less distance from the spill to land and less time for the oil to weather before it reaches the shore. Since oil does not mix with water and is usually less dense, most of the oil forms a slick at the surface. Small droplets in the water may adhere to suspended sediment and be removed from the water column. Oil may also penetrate sand on the beach or be trapped in wetlands, where it can be re-released into the water some time after the initial spill.

In the case of an accidental event, it is likely that response efforts would reduce the amount of oil. **Chapter 3.2.1.5** provides a further discussion of oil-spill-response considerations. Coastal water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification (e.g., dredging, berm building, etc.), and the addition of dispersants and methanol to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree.

One standard tool used in response to spilled oil on water is dispersants. Dispersants are not preauthorized for use in coastal areas (NRC, 2005), but it is possible that the use of dispersants in offshore spills may have effects on coastal environments. The purpose of chemical dispersants is to facilitate the movement of oil into the water column in order to encourage weathering and biological breakdown of the oil (i.e., biodegradation) (NRC, 2005; Australian Maritime Safety Authority, 2010). If the oil moves into the water column and is not on the surface of the water, it is less likely to reach sensitive shore areas (USEPA, 2010h). The toxicity of dispersed oil in the environment will depend on many factors, including the effectiveness of the dispersion, temperature, salinity, the degree of weathering, type of dispersant, and degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, 2010).

Fortunately, over time, natural processes can physically, chemically, and biologically degrade oil (NRC, 2003). The physical processes involved include evaporation, emulsification and dissolution; the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation).

Chemical Spills

A study of chemical spills from OCS activities determined that accidental releases of zinc bromide and ammonium chloride could potentially impact the marine environment (Boehm et al., 2001). Both of these chemicals are used for well treatment or completion and are not in continuous use; thus, the risk of a spill is small. Most other chemicals are either relatively nontoxic or used in such small quantities that a spill would not result in measurable impacts. Zinc bromide is of particular concern because of the toxic

nature of zinc. Close to the release point of an ammonium chloride spill, the ammonia concentrations could exceed toxic levels.

Pipeline Failures

A pipeline failure would result in the release of crude oil, condensate, or natural gas; the impacts of which are discussed above. Pipeline failures are discussed in more detail in **Chapter 3.2.3**.

Fuel Oil Spills from Collisions

A collision may result in the spillage of crude oil, refined products such as diesel, or chemicals. Crude oil and chemicals are discussed in the preceding paragraphs. Diesel is the type of refined hydrocarbon spilled most frequently as the result of a collision. Minimal impacts result from a spill since diesel is light and will evaporate and biodegrade within a few days (USDOC, NOAA, 2006). A collision could result in the release of up to the entire contents of the fuel tanks. Since collisions occur infrequently, the potential impacts to coastal water quality are not expected to be significant.

Summary and Conclusion

Accidental events associated with the CPA proposed action that could impact coastal water quality include spills of oil and refined hydrocarbons, releases of natural gas and condensate, and spills of chemicals or drilling fluids. The loss of well control, pipeline failures, collisions, or other malfunctions could also result in such spills. Although response efforts may decrease the amount of oil in the environment, the response efforts may also impact the environment. Natural degradation processes would also decrease the amount of spilled oil over time. For coastal spills, two additional factors that must be considered are the shallowness of the area and the proximity of the spill to shore. Over time, natural processes can physically, chemically, and biologically degrade oil. Chemicals used in the oil and gas industry are not a significant risk in the event of a spill because they are either nontoxic, used in minor quantities, or are only used on a noncontinuous basis. Spills from collisions are not expected to be significant because collisions occur infrequently.

4.1.1.2.1.4. Cumulative Impacts

A detailed description of cumulative impacts upon water quality can be found in Chapter 4.5.2 of the Multisale EIS and in Chapter 4.1.2.1.4 of the 2009-2012 Supplemental EIS.

Activities in the cumulative scenario that could impact coastal water quality generally include the broad categories of the proposed action and the OCS Program, State oil and gas activity, the activities of other Federal agencies (including the military), natural events or processes, and activities related to the direct or indirect use of land and waterways by the human population (e.g., urbanization, agricultural practices, coastal industry, and municipal wastes). Many of these categories would cause some of the same specific impacts (e.g., vessel traffic would occur for all of those categories except natural processes).

Sediment disturbance and turbidity may result from nearshore pipeline installation, maintenance dredging, disposal of dredge materials, sand borrowing, sediment deposition from rivers, and hurricanes. Turbidity is also influenced by the season. These impacts may be the result of Gulfwide OCS-related activities, State oil and gas activities, the activities of other Federal agencies, and natural processes. Dredging projects related to restoration or flood prevention measures may be directed by the Federal Government for the benefit of growing coastal populations. Chapter 4.1.2.1.7 of the Multisale EIS notes that COE and State permits would require that the turbidity impacts due to pipeline installation be mitigated by using turbidity screens and other turbidity reduction or confinement equipment. These impacts generally degrade water quality locally and are not expected to last for long periods of time.

Vessel discharges can degrade water quality. Vessels may be service vessels supporting the proposed action, OCS-related activities, or State oil and gas activities. However, the vessels may also be vessels used for shipping, fishing, military activities, or recreational boating. Fortunately, for many types of vessels, most discharges are treated or otherwise managed prior to release through regulations administered by USCG and/or USEPA, and many regulations are becoming more stringent. For example,

the USCG Ballast Water Management Program, which was designed to prevent the introduction of invasive species, became mandatory for some vessels in 2004 (33 CFR 151 Subparts C and D) (U.S. Dept. of Homeland Security, CG, 2010b). Furthermore, USCG published the Ballast Water Discharge Standard Notice of Proposed Rulemaking in the *Federal Register* on August 28, 2009. Additionally, the final Vessel General Permit, issued by USEPA, became effective on December 19, 2008. This permit is in addition to already existing NPDES permit requirements and now increases the NPDES regulations so that discharges incidental to the normal operation of vessels operating as a means of transportation are no longer excluded unless exempted from NPDES permitting by Congressional legislation (USEPA, 2008b). These regulations should minimize the cumulative impacts of vessel activities.

Erosion and runoff from nonpoint sources degrade water quality. Nonpoint-source runoff from onshore support facilities could result from OCS-related activities as well as State oil and gas activities and other industries and coastal development. The leading source of contaminants that impair coastal water quality is urban runoff. Urban runoff can include suspended solids, heavy metals and pesticides, oil and grease, and nutrients. Urban runoff increases with population growth, and the Gulf Coast region has experienced a 103 percent population growth since 1970 (USDOC, NOAA, 2008a). The natural emptying of rivers into the GOM as part of the water cycle may introduce chemical and physical factors that alter the condition of the natural water through both natural and anthropogenic sources, such as the addition of waterborne pollutants, or the addition of warmer water, into the GOM through waterbodies emptying into the GOM, runoff, groundwater discharge, or precipitation. Nutrients carried in waters of the Mississippi River contribute to seasonal formation of the hypoxic zone on the Louisiana-Texas shelf. Recently, USEPA has proposed the first set of nutrient standards; the first set of standards is for the State of Florida (USEPA, 2010i). The proposed new water quality standards would set a series of numeric nutrient (nitrogen and phosphorus) limitations for Florida's lakes, rivers, steams, springs, and canals. The USEPA also regulates point-source discharges. Chapter 4.5.2.1 of the Multisale EIS summarizes the regulatory programs designed to protect the waters that enter the Gulf. If these and other water quality programs and regulations continue to be administered and enforced, it is not expected that additional oil and gas activities would adversely impact the overall water quality of the region.

Water quality in coastal waters of the northern Gulf of Mexico is also highly influenced by season. Seasonality influences salinity and dissolved oxygen, nutrient content, temperature, pH and Eh, pathogens, turbidity; metals, and organic compounds.

Since the marine environment is a dynamic system, sediment quality and water quality can affect each other. For example, a contaminant may react with the mineral particles in the sediment and be removed from the water column (e.g., adsorption). Thus, under appropriate conditions, sediments can serve as sinks for contaminants such as metals, nutrients, or organic compounds. However, if sediments are (re)suspended (e.g., due to dredging or a storm event), the resuspension can lead to a temporary redox flux, including a localized and temporal release of any formally sorbed metals as well as nutrient recycling (Caetano et al., 2003; Fanning et al., 1982).

Accidental releases of oil, gas, or chemicals would degrade water quality during and after the spill until either the spill is cleaned up or natural processes degrade or disperse the spill. These accidental releases could be a result of the proposed action, ongoing OCS activity, State oil and gas activity, the transport of commodities to ports, and/or coastal industries. The impacts of rare, catastrophic spills are discussed in **Appendix B**. A catastrophic event would not be expected to occur in coastal waters, but a catastrophic spill in offshore waters could affect coastal waters. The extent of impact from a spill depends on the behavior and fate of oil in the water column (e.g., the movement of oil and the rate and nature of weathering), which, in turn, depends on oceanographic and meteorological conditions at the time (Appendix A.2 and A.3 of the Multisale EIS). Chapter 4.5.2.1 of the Multisale EIS contains more information on accidental releases. A major hurricane can result in a greater number of coastal oil and chemical spill events with increased spill volume and decreases in oil-spill-response times. In the case of an accidental event, it is likely that response efforts would reduce the amount of oil. **Chapter 3.2.1.5** provides further discussion of oil-spill-response considerations. Coastal water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification (e.g., dredging, berm building, etc.) and the addition of dispersants and methanol to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree.

Summary and Conclusion

Water quality in coastal waters would be impacted by sediment disturbance and suspension (i.e., turbidity), vessel discharges, erosion, and runoff from nonpoint-source pollutants including river inflows, seasonal influences, and accidental events. These impacts may be a result of the proposed action and the OCS Program, State oil and gas activity, the activities of other Federal agencies (including the military), natural events or processes, or activities related to the direct or indirect use of land and waterways by the human population (e.g., urbanization, agricultural practices, coastal industry, and municipal wastes). The impacts resulting from the CPA proposed action are a small addition to the cumulative impacts on the coastal waters of the Gulf. Increased turbidity and discharge from the CPA proposed action would be temporary in nature and minimized by regulations and mitigation. Since a catastrophic accident is both rare and not expected to occur in coastal waters, the impact of accidental spills is expected to be small. The incremental contribution of the routine activities and accidental events associated with the proposed action to the cumulative impacts on coastal water quality is not expected to be significant as long as all regulations are followed.

4.1.1.2.2. Offshore Waters

4.1.1.2.2.1. Description of the Affected Environment

A detailed description of offshore water quality can be found in Chapter 3.1.2.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The Gulf of Mexico is the ninth largest waterbody in the world (USDOC, NOAA, 2008a). Over 150 rivers empty out of North America into the Gulf of Mexico (Gore, 1992, p. 127). The majority of this input is accounted for by the two largest United States Deltas, the Mississippi and the 5-river Mobile Bay System (Gore, 1992, p. 127). The river deltas emptying into the Gulf bring freshwater and sediment into coastal waters (Gore, 1992, pp. 127-131), which affect the water quality of these waters. Rivers carry excess nutrients (e.g., nitrogen and phosphorus), as well as other possible inputs such as contaminants from industrial wastewater discharge, downstream; and this effect is cumulative as the river reaches an estuary (Gore, 1992, pp. 280 and 291). The emptying of rivers into the GOM is part of the hydrologic cycle or water cycle (USDOI, GS, 2010a); understanding this cycle not only explains the movement of water on Earth but also how water quality might be affected by both natural and anthropogenic sources. The water cycle may introduce components into the GOM through waterbodies emptying into the GOM, runoff, groundwater discharge, or precipitation. Water quality can be affected by not only chemical processes but also by physical and biological processes. For example, the water quality of the Gulf of Mexico is influenced by the physical oceanography of the Gulf of Mexico, which is described in Appendix A.2 of the Multisale EIS. Besides nutrients, water quality is generally gauged by measuring a series of parameters commonly including, but not limited to, temperature, salinity, dissolved oxygen, pH, Eh, pathogens, and turbidity. Water quality may also examine possible pollutants such as metals and organic compounds.

The water offshore of the Gulf's coasts can be divided into two regions: shallow (<1,000 ft; 305 m) and deep water (>1,000 ft; 305 m). Waters on the continental shelf (0-200 m; 0-656 ft) and slope (200-2,000 m; 656-6,562 ft) are heavily influenced by the Mississippi and Atchafalaya Rivers, the primary sources of freshwater, sediment, nutrients, and pollutants from a huge drainage basin encompassing 55 percent of the continental U.S. (Murray, 1998). The presence or extent of a nepheloid layer, a body of suspended sediment at the sea bottom (Kennet, 1982, p. 524), affects water quality on the shelf and slope. Deep waters east of the Mississippi River are affected by the Loop Current and associated warm-core (anticyclonic) eddies, which consist of clear, low-nutrient water (Muller-Karger et al., 2001). However, cold-core cyclonic eddies (counterclockwise rotating) also form at the edge of the Loop Current and are associated with upwelling and nutrient-rich, high-productivity waters. More details on the physical oceanography of the Gulf of Mexico are available in Appendix A.2 of the Multisale EIS and in **Chapter 3.3.7.1** of this Supplemental EIS.

Seawater generally averages pH 8 at the surface due to marine systems being buffered by carbonates and bicarbonates; however, in the open waters of the Gulf of Mexico, pH ranges from approximately 8.1 to 8.3 at the surface (Gore, 1992, p. 87). The pH decreases to approximately 7.9 at a depth of 700 m (2,297 ft), and in deeper waters, it increases again to approximately 8.0 (Gore, 1992, p. 87).

The salinity in the Gulf of Mexico is generally 36 ppt (Gore, 1992, p. 87). Lower salinities are characteristic nearshore where freshwater from the rivers mix with Gulf waters. For example, salinity can decrease to less than 25 ppt near inlets due to the emptying of rivers (runoff) (Gore, 1992, p. 81). Salinity also varies seasonally. For example, salinity in open water near the coast may vary between 29 and 32 practical salinity units (psu) during fall and winter but decline to 20 psu during spring and summer due to increased runoff (USDOI, MMS, 2000) (practical salinity units [psu] are similar to parts per thousand [ppt], but not identical).

Temperatures in the Gulf of Mexico vary seasonally. The average summer surface temperature is approximately 29 ºC (84 ºF) (Gore, 1992, p. 79). In winter, temperature in the northern Gulf is 19 ºC (65 F) and in the southern portion of the Gulf, it is about 24 ºC (75 ºF) (Gore, 1992, p. 79). However, temperatures may dip lower during cold fronts. In winter, seawater is well mixed (Gore, 1992, p. 80). At other times, sea-surface temperatures can vary from temperatures at depth. In the summer, warm water may be found from the surface down to a certain depth known at the thermocline; below this depth, the temperature becomes cooler and therefore the water becomes denser (Gore, 1992, pp. 79-80). In the Gulf, the thermocline may be found anywhere from just below the surface to 160 ft (50 m) deep. Seawater also gets colder in deep water. Below 1,000 m (about 3,300 ft), temperatures are the coldest in the Gulf at <4.4 ºC (40 ºF).

Dissolved oxygen enters the upper waters (~100-200 m; 328-656 ft) of Gulf of Mexico through the atmosphere and photosynthesis (Jochens et al., 2005). In deep waters, dissolved oxygen is introduced through the transport and mixing of oxygen-rich watermasses into the Gulf of Mexico from the Caribbean Sea through the Yucatan Channel (Jochens et al., 2005). The Gulf of Mexico does not have watermass formation to replenish the deep oxygen concentrations (Jochens et al., 2005). Thus, the deep circulation of the Gulf of Mexico and its related mixing are the mechanisms that replenish the deep oxygen (Jochens et al., 2005). Oxidation of organic matter is the major oxygen sink in the Gulf of Mexico (Jochens et al., 2005). The Gulf of Mexico has an oxygen minimum zone, which is generally located from 300 to 700 m (984 to 2,297 ft) (Jochens et al., 2005).

The zone of hypoxia on the Louisiana-Texas shelf occurs seasonally and is affected by the timing of the Mississippi and Atchafalaya Rivers' discharges carrying nutrients to the surface waters. The hypoxic conditions last until local wind-driven circulation mixes the water again. The 2010 GOM dead zone covered 20,000 km^2 (7,722 mi^2) (LUMCON, 2010a). Nutrients from the Mississippi River fueling enhanced phytoplankton is what was attributed to the formation of the hypoxic zone. The 2010 dead zone was reported to be one of the largest ever. The area reported in 2009 measured 8,000 km^2 (3,000 mi^2) (LUMCON, 2009), while the area reported in 2008 measured 20,720 km^2 (8,000 mi^2) (LUMCON, 2008).

The priority, water quality issues identified by the Gulf of Mexico Alliance are (1) reducing risk of exposure to disease-causing pathogens, (2) minimizing occurrence and effects of harmful algal blooms, (3) identifying sources of mercury in Gulf seafood, and (4) improving the monitoring of Gulf water resources (Gulf of Mexico Alliance, 2009a). In addition to water quality itself, nutrients and nutrient impacts are also a regional priority issue for the organization (Gulf of Mexico Alliance, 2009b).

As noted above, coastal waters are greatly affected by runoff. Runoff may include any number of pollutants such as nutrients, pesticides and other organic chemicals, and metals. Shallow water on the shelf and slope are also affected by runoff. The National Research Council (2003, Table I-4, p. 237) estimated that, on average, approximately 26,324 bbl of oil per year entered Gulf waters from petrochemical and oil refinery industries in Louisiana and Texas. The Mississippi River introduced approximately 3,680,938 bbl of oil and grease per year from land-based sources (NRC, 2003, Table I-9, p. 242) into the waters of the Gulf of Mexico. Offshore waters, especially deeper waters, are more directly affected by natural seeps since the natural seeps in the Gulf of Mexico are located in offshore waters. Hydrocarbons enter the Gulf of Mexico through natural seeps in the Gulf of Mexico at a rate of approximately 980,392 bbl per year (a range of approximately 560,224-1,400,560 bbl per year) (NRC, 2003, p. 191). Hydrocarbons from natural seeps are considered to be the highest contributor of petroleum hydrocarbons to the marine environment (NRC, 2003, p. 33). Produced water (formation water) is the largest waste stream by volume from the oil and gas industry that enters Gulf waters. Produced water is

commonly treated to separate free oil and is either injected back into the reservoir or discharged overboard according to NPDES permit limits. The NRC has estimated the quantity of oil in produced water entering the Gulf per year to be 473,000 bbl (NRC, 2003, p. 200, Table D-8). These numbers were generated from converting the units reported in the noted reference and do not imply any level of significance. The numbers in this paragraph were generated from converting the units reported in the noted reference and do not imply any level of significance.

Since the marine environment is a dynamic system, sediment quality and water quality can affect each other. For example, a contaminant may react with the mineral particles in the sediment and be removed from the water column (e.g., adsorption). Thus, under appropriate conditions, sediments can serve as sinks for contaminants such as metals, nutrients, or organic compounds. However, if sediments are (re)suspended (e.g., due to dredging or a storm event), the resuspension can lead to a temporary redox flux, including a localized and temporal release of any formally sorbed metals as well as nutrient recycling (Caetano et al., 2003; Fanning et al., 1982). However, resuspension events are less likely in deepwater environments. Deepwater sediments, with the exception of barium concentrations in the vicinity of previous drilling, do not appear to contain elevated levels of metal contaminants (USDOI, MMS, 1997 and 2000). The western Gulf has lower levels of total organic carbon and hydrocarbons in sediment, particularly those from terrestrial sources, than the central Gulf (Gallaway and Kennicutt, 1988). Reported total hydrocarbons, including biogenic (e.g., from biological sources) hydrocarbons, in sediments collected from the Gulf slope range from 5 to 86 nanograms/gram (Kennicutt et al., 1987). Hydrocarbons in sediments have been determined to influence biological communities of the Gulf slope, even when present in trace amounts (Gallaway and Kennicutt, 1988).

A 3-year, environmental baseline study conducted from 1974 to 1977 in the eastern GOM resulted in an overview of the Mississippi, Alabama, and Florida (MAFLA) OCS environment to 200 m (656 ft) (SUSIO, 1977; Dames & Moore, Inc., 1979). Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is relatively pristine, with some influence of anthropogenic and petrogenic hydrocarbons from river sources. Analysis of trace metal contamination for the trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination. A decade later, the continental shelf off Mississippi and Alabama was revisited (Brooks, 1991). Bottom sediments were analyzed for high-molecular-weight hydrocarbons and heavy metals. High-molecular-weight hydrocarbons can come from natural petroleum seeps at the seafloor or recent biological production as well as input from anthropogenic sources. In the case of the Mississippi-Alabama shelf, the source of petroleum hydrocarbons and terrestrial plant material is the Mississippi River. Higher levels of hydrocarbons were observed in the late spring, which coincides with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks, 1991).

Limited information is available on water quality in deep waters. Water at depths >1,400 m (4,593 ft) is relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin, 1972; Pequegnat, 1983; Gallaway et al., 1988; Jochens et al., 2005). Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefry, 1981; Gallaway et al., 1988). Continental Shelf Associates, Inc. (CSA) completed an Agency-funded field study of four drilling sites located in water depths of 1,033-1,125 m (3,389-3,691 ft) (CSA, 2006a). The sampling design called for before and after exploratory or development drilling and captured the drilling-related changes that occur in sediments and sediment pore water. At the Viosca Knoll Block 916 site, the closest drilling activity had occurred 1.4 mi (2.3 km) north-northwest and 2 years prior to the study; no drilling had ever been performed at the Viosca Knoll Block 916 site. The site was located at a water depth of 1,125 m (3,691 ft) and 70 mi (120 km) from the mouth of the Mississippi River. At this relatively pristine site prior to drilling, the average sediment barium concentration was 870-1,090 micrograms/gram. The average sediment mercury and cadmium concentrations were 0.071 and 0.22-0.28 micrograms/gram, respectively. The range of total sediment PAH's was 159-388 nanograms/gram before drilling.

Despite more limited information on the water quality of deep water, it is clear that the condition of the offshore waters of the Gulf of Mexico was altered by the DWH event and resulting oil spill. It is currently impossible to estimate precisely the long-term impacts that the spill from the DWH event will have on offshore water quality. Since the DWH event and resulting spill occurred in offshore waters and was of considerable magnitude, many of considerations noted in the chapter above on coastal water

impacts also apply for offshore waters. Various monitoring efforts and environmental studies have already begun. At the time this Supplemental EIS was prepared, the following sources were used for general information concerning the DWH event:

- BP website on the DWH event (http://www.bp.com/sectiongenericarticle800.do?categoryId=9036575&contentId=7067541);
- Restore the Gulf website on the DWH response (http://www.data.gov/restorethegulf/);
- USEPA website on response to the BP spill in the Gulf of Mexico (http://www.epa.gov/bpspill/epa.html);
- National Science Foundation website on rapid response grants to fund DWH research (http://nsf.gov/awardsearch/progSearch.do?SearchType=progSearch&page=2&QueryText=&ProgOrganization=&ProgOfficer=&ProgEleCode=&BooleanElement=false&ProgRefCode=5987&BooleanRef=false&ProgProgram=&ProgFoaCode=&Restriction=2&Search=Search#results);
- Sea Grant website on DWH oil-spill research and monitoring activities database (http://gulfseagrant.tamu.edu/oilspill/database.htm); and
- Joint Analysis Group review of R/V *Brooks McCall* data to examine subsurface oil (http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf).

More time is needed to fully assess the impacts of the DWH event. Although response efforts have decreased the fraction of oil remaining in Gulf waters and reduced the amount of oil contacting the coastline, significant amounts of oil remain (RestoreTheGulf.gov, 2010a).

Offshore water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification, and the addition of dispersants, methanol, and water-based drilling mud to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree. Fortunately, over time, natural processes can physically, chemically, and biologically degrade oil (NRC, 2003). The physical processes involved include evaporation, emulsification and dissolution; the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation).

The oil that entered the Gulf of Mexico from the DWH event is a South Louisiana sweet crude oil (i.e., it is low in sulfur) (USDOC, NOAA, 2010b). The oil is fairly high in alkanes (organic compounds containing only carbon and hydrogen and single bonds, sometimes called paraffin or aliphatic compounds) (USDOC, NOAA, 2010b). Because alkanes are simple hydrocarbons, these oils are likely to undergo biodegradation more easily (USDOC, NOAA, 2010b). Weathering of crude can occur within the first 24-48 hours with up to a 40 percent weight loss within 7 days (English, 2010). Also, this oil is less toxic than other crude oils in general because this oil is lower in PAH's than many crude oils.

The DWH event released natural gas into the water column in addition to oil. Methane is the primary component of natural gas (NaturalGas.org, 2010b). Limited research is available for the biogeochemistry of hydrocarbon gases in the marine environment (Patin, 1999, p. 233). Methane may stay in the marine environment for long periods of time (Patin, 1999, p. 237) as methane is highly soluble in sea water at the high pressures and cold temperatures found in deepwater environments (NRC, 2003, p. 108); however, methane diffusing through the water column would likely be oxidized in the aerobic zone and would rarely reach the air-water interface (Mechalas, 1974, p. 23). Unfortunately, little is known about methane toxicity in the marine environment, but there is concern as to how methane in the water column might affect fish (**Chapter 4.1.1.16**).

One tool that was used in response to the oil leaking into the Gulf of Mexico from the DWH event is dispersants. The purpose of chemical dispersants is to facilitate the movement of oil into the water column in order to encourage weathering and biological breakdown of the oil (i.e., biodegradation) (NRC, 2005; Australian Maritime Safety Authority, 2010). The amounts of dispersant sprayed at the surface and injected at the wellhead are 1,072,514 gallons and 771,272 gallons, respectively (U.S. Dept. of Homeland Security, CG, 2010c). The fate of this dispersant remains under study. If the oil moves into the water column and is not on the surface of the water, it is less likely to reach sensitive shore areas (USEPA, 2010h). In addition to dispersion being enhanced by artificial processes, oil my also be dispersed from natural processes. For example, microbial metabolism of crude oil results in the dispersion of oil (Bartha and Atlas, 1983). Dispersion has both positive and negative effects. The positive effect is that the oil, once dispersed, is more available to be degraded. The negative effect is that the oil, once dispersed, is more available to microorganisms, which temporarily increase the toxicity (Bartha and Atlas, 1983). Toxicity of dispersed oil in the environment would depend on many factors, including the effectiveness of the dispersion, temperature, salinity, the degree of weathering, type of dispersant, and the degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, 2010).

Corexit 9500 and *9527* have been used in the DWH event response (USEPA, 2010h). The components of these dispersants are identical, with the exception of the base solvent; Corexit 9527 has an organic solvent as a base (McDonald et al., 1984; USEPA, 2010h). Dispersants used in the 1960's were quite toxic, but more recently developed dispersants such as *Corexit* are considerably less toxic (Doe and Wells, 1978; Leahy and Colwell, 1990). Lindstrom and Braddock (2002) found that environmental use of *Corexit 9500* could result in either increases or decreases in the toxicity of residual oil through selective microbial mineralization of hydrocarbons. In fact, reviews of studies have found that the general effectiveness of dispersants in enhancing biodegradation of crude oil and individual hydrocarbons is highly variable and depends on several factors, including the chemical formulation of the dispersant, its concentration, and the dispersant/oil application ratio (Boehm, 1983). However, there was evidence that the dispersants worked in the case of the DWH event (USDOC, NOAA, 2010a; USEPA, 2010h). Corexit 9527 has been shown to greatly increase volatile liquid hydrocarbons' incorporation into water as well as to accelerate the process in experiments compared with if no dispersant was used (McDonald et al., 1984). In fact, dispersants used during the DWH event has been noted to reduce the volatile organic compounds, which can be a workplace issue for response workers on ships near the site (White House Press Briefing, 2010). Since the amount of dispersants used in the DWH event is unprecedented and since this is the first time dispersants have been applied in deep waters, continual monitoring and evaluation of their use is imperative (White House Press Briefing, 2010).

As a result of the use of subsea dispersants, clouds or plumes of dispersed oil may occur near the blowout site in offshore waters. Reports thus far from the DWH event found such plumes and have shown that the concentrations of these clouds drop to undetectable levels within a few miles (USDOC, NOAA, 2010b). Dissolved oxygen levels are a concern with any release of a carbon source, such as oil and natural gas, and became a particular concern during the DWH event since dispersants were used in deep waters for the first time. Thus, USEPA required monitoring protocols in order to use subsea dispersants (USDOC, NOAA, 2010c). In areas where plumes of dispersed oil were previously found, dissolved oxygen levels decreased by about 20 percent from long-term average values in the GOM; however, scientists reported that these levels have stabilized and are not low enough to be considered hypoxic (USDOC, NOAA, 2010d). The drop in oxygen, which has not continued over time, has been attributed to microbial degradation of the oil. Initially released studies indicate that bacteria are degrading hydrocarbons from both gas and oil, but the degradation rates reported in the studies varied considerably (Camilli et al., 2010; Hazen et al., 2010; Valentine et al., 2010). Over time, as the oil continues to be degraded and diffuses, hypoxia becomes less of a concern. In fact, the 2010 hypoxic zone could not be linked to the DWH event in either a positive or a negative manner (LUMCON, 2010a).

During the DWH event, one of the earlier attempts to stop the oil from leaking from the well was a procedure called a "top kill" (RestoreTheGulf.gov, 2010b). The top kill involved using water-based drilling muds, which are heavy due to the mineral component barite, in order to stop flow from the well. This procedure was not successful, but during the procedure, 29,712 bbl of water-based mud were used (Boland, personal communication, 2010). Much of this mud ended up on the seafloor. The primary general components of water-based mud (also referred to as water-based drilling fluids) are fresh or

saltwater, barite, clay, caustic soda, lignite, lignosulfonates, and water soluble polymers (USDOI, BOEMRE, 2010h). Water-based drilling mud may be discharged to the ocean under normal operations, but those discharges are regulated by USEPA (USDOI, BOEMRE, 2010h). The BOEMRE research has shown that drilling mud discharges do not move very far, even when discharged at the surface (CSA, 2006a). Since the muds were discharged in deep water, sediments in the area are likely to be affected.

4.1.1.2.2.2. Impacts of Routine Events

Background/Introduction

A detailed description of routine impacts on offshore water quality can be found in Chapter 4.2.1.1.2.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.2.2 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

The routine activities associated with the CPA proposed action that would impact water quality include the following:

- discharges during drilling of exploration and development wells;
- structure installation and removal;
- discharges during production;
- installation of pipelines;
- workovers of wells,
- maintenance dredging of existing navigational canals;
- service vessel discharges; and
- nonpoint-source runoff.

The scenario information related to the CPA proposed action is presented in **Table 3-2.**

The USEPA regulates discharges associated with offshore oil and gas exploration, development, and production activities on the OCS under the Clean Water Act's NPDES program. Regulated wastes include drilling fluids, drill cuttings, deck drainage, produced water, produced sand, well treatment fluids, well completion fluids, well workover fluids, sanitary wastes, domestic wastes, and miscellaneous wastes (USEPA, 2009a). The USEPA's NPDES general permit for Region 6 (GMG290000, which authorizes discharges to surface water during drilling and production) was reissued and went into effect on October 1, 2007 (USEPA, 2007c). This permit covers a large portion of the CPA, as USEPA's regional boundaries do not coincide with BOEMRE's planning area boundaries. The permit will expire on September 30, 2012. The USEPA Region 4 issues individual and general permits covering facilities that discharge in water depths seaward of 200 m (656 ft) occurring offshore the coasts of Alabama and Florida. The western boundary of the coverage area is demarcated by Mobile and Viosca Knoll lease blocks located seaward of the boundary of the territorial seas from the coasts of Mississippi and Alabama. The USEPA Region 4's NPDES general permit (GMG460000) for offshore oil and gas activities in Federal waters in the eastern portion of the OCS of the Gulf of Mexico (off of the coast of Mississippi and eastward) expired on December 31, 2009 (USEPA, 2009b). The USEPA Region 4 issued the new permit, GEG460000, on March 15, 2010, and it expires on March 21, 2015 (USEPA, 2010j). The changes in the new permit include the following: (1) the permit number; (2) requirements for cooling water intake structures (similar requirements are already in effect in Region 6); (3) best management practices plan requirements to address discharges of debris from blasting and painting activities; (4)

clarifications of the testing procedures for determining the degradation of nonaqueous base fluids in a marine, closed-bottle, biodegradation test system; (5) clarifications for the reporting requirements for ratio values used to report compliance with the sediment toxicity and biodegradation tests; and (6) the requirement to perform a seabed survey was deleted since the industry completed this study during the term of the previous permit (USEPA, 2009b). Thus, the permit is similar to the previous permit with the exception of the clarifications and more stringent requirements noted above.

The bulk of waste materials produced by offshore oil and gas activities are formation water (produced water) and drilling muds and cuttings. All of these waste streams are regulated by USEPA through NPDES permits. Characteristics of drilling muds and cuttings, the impacts of discharge, and regulatory controls are discussed in great detail in Chapter 4.1.1.4.1 of the Multisale EIS. The CPA proposed action is projected to result in the drilling of a total of 65-121 exploratory and delineation wells and 338-576 development and production wells (**Table 3-2**). Muds are the weighted fluids used to lubricate the drill bit, and cuttings are the ground rock displaced from the well. Drilling muds generally consist of clays, barite, lignite, caustic soda (sodium hydroxide), lignosulfonates, and a base fluid such as freshwater, saltwater, mineral oil, diesel oil, or a synthetic oil (USDOI, BOEMRE, 2010h; NRC, 1983; USEPA, 2009a); however, the exact formulas are complex and vary. Three general types of drilling muds have been used during drilling operations: water-based drilling muds (WBM or WBF), oil-based drilling muds (OBM or OBF), and synthetic-based drilling muds (SBM or SBF). The WBM and WBM-wetted cuttings may be discharged. The OBM's are used to improve drilling through difficult geologic formations. The base mud for OBM is typically diesel or mineral oil. Because these oils often contain toxic materials such as PAH's, the discharge of OBM or cuttings wetted with OBM is prohibited. The SBM's were developed as an alternative to OBM. The base fluid is a synthetic material, typically an olefin or ester, free of toxic PAH's. Discharge of SBM is prohibited and, due to cost, is generally recycled (USEPA, 2009a). However, SBM-wetted cuttings may be discharged after the majority of the SBM has been removed. Water-based muds and cuttings that are discharged increase turbidity in the water column and alter the sediment characteristics in the area where they settle (Neff, 2005). The SBF-wetted cuttings do not disperse as readily in water and descend in clumps to the seafloor (Neff et al., 2000). The SBF on the wetted cuttings gradually breaks down and may deplete the oxygen level at the sediment water interface as it degrades (Neff et al., 2000).

During production, produced water is brought up from the hydrocarbon-bearing strata along with the oil and gas that is generated. Characteristics of produced water, the impacts of discharge, and regulatory controls are discussed in greater detail in Chapter 4.1.1.4.2 of the Multisale EIS. The scenario for the CPA projects that 338-576 development and production wells would be drilled, of which 149-263 are expected to be producing oil wells and 144-237 are expected to be producing gas wells (**Table 3-2**). Greater volumes of produced water are associated with oil rather than with gas production; in fact, a report on produced-water volumes in the United States noted that 87 percent of produced water came from oil production (Clark and Veil, 2009). Produced water may contain dissolved solids in higher concentrations than Gulf waters, metals, hydrocarbons, and naturally-occurring radionuclides (Veil et al., 2004). Produced water may contain residuals from the treatment completion or workover compounds used, as well as additives used in the oil/water separation process (Veil et al., 2004). Produced water is treated to meet NPDES requirements before it is discharged.

Additional chemical products are used to "workover" or treat a well. These wastes are regulated by USEPA through the NPDES program as noted above. Characteristics of workover treatment and production chemicals, the impacts of discharge, and regulatory controls are discussed in greater detail in Chapter 4.1.1.4.3 of the Multisale EIS. Some examples of chemicals that might be used to "workover" or treat a well include, but are not limited to, brines used to protect a well, acids used to increase well production, and miscellaneous products used to separate water from oil, to prevent bacterial growth, or to eliminate scale formation or foaming (Boehm et al., 2001).

During structure installation and removal, impacts from anchoring, mooring, pipeline and flowline emplacement, and the placement of subsea production structures may occur. The CPA proposed action is projected to result in the installation of 32-44 structures and the removal of 30-42 structures (**Table 3-2**). The CPA proposed action is also projected to result in the installation of 130-2,075 km (~81-1,289 mi) of pipeline. Additional information on bottom-area disturbance is available in Chapter 4.1.1.3.2.1 of the Multisale EIS. More specifically, a description of the pipeline installation is provided in Chapter 4.1.1.8.1 of the Multisale EIS. In the report titled *Brief Overview of Gulf of Mexico OCS Oil and Gas*

Pipelines: Installation, Potential Impacts, and Mitigation Measures (Cranswick, 2001), the report states the following:

> According to MMS regulations (30 CFR 250.1003(a)(1)), pipelines with diameters ≥8 5/8 inches that are installed in water depths <200 ft are to be buried to a depth of at least 3 ft below the mudline. The regulations also provide for the burial of any pipeline, regardless of size, if the MMS determines that the pipeline may constitute a hazard to other uses of the OCS; in the GOM, the MMS has determined that all pipelines installed in water depths <200 ft must be buried. The purpose of these requirements is to reduce the movement of pipelines by high currents and storms, to protect the pipeline from the external damage that could result from anchors and fishing gear, to reduce the risk of fishing gear becoming snagged, and to minimize interference with the operations of other users of the OCS. For lines 8 5/8 inches and smaller, a waiver of the burial requirement may be requested and may be approved if the line is to be laid in an area where the character of the seafloor will allow the weight of the line to cause it to sink into the sediments (self-burial). For water depths ≤200 ft, any length of pipeline that crosses a fairway or anchorage in Federal waters must be buried to a minimum depth of 10 ft below mudline across a fairway and a minimum depth of 16 ft below mudline across an anchorage area. Some operators voluntarily bury these pipelines deeper than the minimum.

Any disturbance of the seafloor would increase turbidity in the surrounding water, but the increased turbidity should be temporary and restricted to the area near the disturbance.

Service-vessel discharges include bilge and ballast water and sanitary and domestic waste. The CPA proposed action is projected to result in 137,000-220,000 service-vessel round trips (**Table 3-2**). A marine sanitation device is required to treat sanitary waste generated on the service vessel so that surrounding water would not be impacted by possible bacteria or viruses in the waste (40 CFR 140 and 33 CFR 159). The discharge of treated sanitary waste would still contribute a small amount of nutrients to the water. A description of service-vessel operational wastes is provided in Chapter 4.1.1.4.8 of the Multisale EIS. Oil may contaminate bilge and, although less likely, ballast water. The regulations for the control of oil discharges are in 33 CFR 151.10. When more than 12 nmi (14 mi; 22 km) from the nearest land, bilge and ballast water may generally be discharged with an oil content of less than 15 ppm. While within 12 nmi (14 mi; 22 km), the oil content of the effluent must not exceed 15 ppm. The discharges would affect the water quality locally. However, regulations regarding discharges from vessels are becoming increasingly stringent. The USCG Ballast Water Management Program became mandatory for some vessels in 2004 (33 CFR 151 Subparts C and D) (U.S. Dept. of Homeland Security, CG, 2010b). The program was designed to prevent the introduction on nonindigenous (invasive) species, which would affect local water quality. Furthermore, USCG published the Ballast Water Discharge Standard Notice of Proposed Rulemaking in the *Federal Register* on August 28, 2009. Additionally, the final Vessel General Permit, issued by USEPA, became effective on December 19, 2008. This permit is in addition to already existing NPDES permit requirements and now increases the NPDES regulations so that discharges incidental to the normal operation of vessels operating as a means of transportation are no longer excluded unless exempted from NPDES permitting by Congressional legislation (USEPA, 2008b).

Summary and Conclusion

During exploratory activities, the primary impacting sources to offshore water quality are discharges of drilling fluids and cuttings. During platform installation and removal activities, the primary impacting sources to water quality are sediment disturbance and temporarily increased turbidity. Impacting discharges during production activities are produced water and supply-vessel discharges. Regulations are in place to limit the levels of contaminants in these discharges. Pipeline installation can also affect water quality by sediment disturbance and increased turbidity. Service-vessel discharges might include water with oil concentration of approximately 15 ppm as established by regulatory standards. Any disturbance of the seafloor would increase turbidity in the surrounding water, but the increased turbidity should be temporary and restricted to the area near the disturbance. There are multiple Federal regulations and

permit requirements that would decrease the magnitude of these activities. Impacts to offshore waters from routine activities associated with the CPA proposed action should be minimal as long as regulatory requirements are followed.

4.1.1.2.2.3. Impacts of Accidental Events

A detailed description of accidental events on offshore water quality can be found in Chapter 4.4.2.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.2.2.3 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Accidental events associated with the CPA proposed action that could impact offshore water quality include spills of oil and refined hydrocarbons, releases of natural gas, spills of chemicals or drilling fluids, and loss of well control, collisions, or other malfunctions that would result in such spills. **Chapter 3.2** of this document discusses the accidental events that could result from the impact-producing factors and scenario, with particular attention given to the risk of oil spills, response to such oil spills, loss of well control, pipeline failures, vessel collisions, and chemical and drilling fluid spills. A brief summary is presented here. The impacts of rare, catastrophic spills are discussed in **Appendix B**.

Proposed Action Analysis

Oil Spills and Natural Gas and Condensate Releases

Water quality is altered and degraded by oil spills through the increase of petroleum hydrocarbons and their various transformation/degradation products in the water. The extent of impact from a spill depends on the behavior and fate of oil in the water column (e.g., the movement of oil and the rate and nature of weathering), which, in turn, depends on oceanographic and meteorological conditions at the time (Appendix A-2 and A-3 of the Multisale EIS). Crude oils are not a single chemical, but instead are complex mixtures with varied compositions. The various fractions within the crude behave differently in water. Thus, the behavior of the oil and the risk that the oil poses to natural resources depends on the composition of the specific oil encountered (Michel, 1992). Generally, oils can be divided into three groups of compounds: (1) light-weight; (2) medium-weight; and (3) heavy-weight components. **Chapter 3.2.1** further characterizes the components of oil and discusses oil spills. Chapter 4.3.1 of the Multisale EIS also discusses oil spills in further detail, with Chapter 4.3.1.4 of the Multisale EIS describing the characteristics of OCS oil. Generally, the lighter ends of the oil are more water soluble and would contribute to acute toxicity. As the spill weathers, the aromatic components at the water's surface are more likely to exit the water. The heavier fractions are less water soluble and would partition to organic matter. This fraction is more likely to persist in sediments and would contribute to longer-term impacts.

In addition to oil, natural gas may also be explored for or produced in the GOM. Wells and sidetracks may produce a mixture of both oil and natural gas. Condensate is a liquid hydrocarbon phase that generally occurs in association with natural gas. The quality and quantity of components in natural gas vary widely by the field, reservoir, or location from which the natural gas is produced. Although there is not a "typical" makeup of natural gas, it is primarily composed of methane (NaturalGas.org, 2010b). Thus, if natural gas were to leak into the environment, methane may be released to the environment. Methane is a carbon source, such as oil, and its introduction into the marine environment could result in lowering dissolved oxygen levels due to increased microbial degradation. Unfortunately, little is known about the toxicity of natural gas and its components in the marine environment, but there is concern as to how methane in the water column might affect fish (**Chapter 4.1.1.13**).

Hydrogen sulfide (H_2S), a toxic gas that is associated with certain formations in the GOM, could be released with natural gas. Depending on the concentration and volume, an H_2S release at the seafloor could negatively impact the water quality as the gas rises to the surface (Patin, 1999).

The National Academy of Sciences (NRC, 2003), Patin (1999), and Boesch and Rabalais (1987) have reviewed the fate and effects of spilled oil and, to a lesser degree, natural gas releases. Chapters 4.3.1.5 and 4.3.1.6 of the Multisale EIS presents the risk of offshore spills associated with the proposed action, and **Chapters 3.2.1.1 and 3.2.1.2** of this Supplemental EIS supplement and update that information. Oil spills at the water surface may result from a platform accident. Subsurface spills are more likely to occur

from pipeline failure or a loss of well control. As noted above, the behavior of a spill depends on many things, including the characteristics of the oil being spilled as well as oceanographic and meteorological conditions. An experiment in the North Sea indicated that the majority of oil released during a deepwater blowout would quickly rise to the surface and form a slick (Johansen et al., 2001). In such a case, impacts from a deepwater oil spill would occur at the surface where the oil is likely to be mixed into the water and dispersed by wind and waves. The oil would undergo natural physical, chemical, and biological degradation processes including weathering. However, data and observations from the DWH event challenged the previously prevailing thought that most oil from a deepwater blowout would quickly rise to the surface. While analyses are in their preliminary stages, it appears that measurable amounts of hydrocarbons (dispersed or otherwise) are being detected in the water column as subsurface plumes (**Chapter 4.1.1.2.2.1**) and perhaps on the seafloor in the vicinity of the release. After the *Ixtoc* blowout in 1979, which was located 50 mi (80 km) offshore in the Bay of Campeche, Mexico, some subsurface oil also was observed dispersed within the water column (Boehm and Fiest, 1982); however, the scientific investigations were limited (Reible, 2010). The water quality of offshore waters would be affected by the dissolved components and oil droplets that are small enough that they do not rise to the surface or are mixed down by surface turbulence. In the case of subsurface oil plumes, it is important to remember that these plumes would be affected by subsurface currents and could be diluted over time. Even in the subsurface, oil would undergo natural physical, chemical, and biological degradation processes including weathering.

In the case of an accidental event, it is likely that response efforts would reduce the amount of oil. **Chapter 3.2.1.5** provides a further discussion of oil-spill-response considerations. Offshore water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, top kill attempts involving the use of drilling muds, and the addition of dispersants and methanol to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree.

Top kills use drilling muds, which are heavy due to the mineral component barite, in order to stop flow from a well. Top kill methods would likely involve the use of water-based drilling muds, which may be discharged to the ocean under normal operations as regulated by USEPA (USDOI, BOEMRE, 2010h). Depending on the success of the procedure, a portion of the mud could end up on the seafloor since drilling mud discharges do not move far from where they are released (CSA, 2006a). See "Accidental Release of Drilling Fluids" below for more information.

One standard tool used in response to spilled oil on water is dispersants. The purpose of chemical dispersants is to facilitate the movement of oil into the water column in order to encourage weathering and biological breakdown of the oil (i.e., biodegradation) (NRC, 2005; Australian Maritime Safety Authority, 2010). If the oil moves into the water column and is not on the surface of the water, it is less likely to reach sensitive shore areas (USEPA, 2010h). The toxicity of dispersed oil in the environment would depend on many factors, including the effectiveness of the dispersion, temperature, salinity, the degree of weathering, type of dispersant, and the degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, 2010).

In addition to response efforts, the natural environment can attenuate some oil. The Gulf of Mexico has numerous natural hydrocarbon seeps as discussed in Chapters 3.1.2.2 and 4.1.3.4.1 of the Multisale EIS. Thus, the marine environment can be considered adapted to handling small amounts of oil released over time. Furthermore, over time, natural processes can physically, chemically, and biologically degrade oil (NRC, 2003). The physical processes involved include evaporation, emulsification, and dissolution; the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation). Most of the oil spills that may occur as a result of the proposed action are expected to be ≤1 bbl (**Table 3-5**).

Chemical Spills

A study of chemical spills from OCS activities determined that accidental releases of zinc bromide and ammonium chloride could potentially impact the marine environment (Boehm et al., 2001). Both of these chemicals are used for well treatment or completion and are not in continuous use; thus, the risk of a spill is small. Most other chemicals are either relatively nontoxic or used in such small quantities that a

spill would not result in measurable impacts. Zinc bromide is of particular concern because of the toxic nature of zinc. Close to the release point of an ammonium chloride spill, the ammonia concentrations could exceed toxic levels.

Accidental Releases of Drilling Fluids

Drilling muds or fluids are the weighted fluids used to lubricate the drill bit. Drilling muds generally consist of clays, barite, lignite, caustic soda (sodium hydroxide), lignosulfonates, and a base fluid such as freshwater, saltwater, mineral oil, diesel oil, or a synthetic oil (USDOI, BOEMRE, 2010h; NRC, 1983; USEPA, 2009a); however, the exact formulas are complex and vary. The impacts of discharge and regulatory controls of drilling muds are discussed in great detail in Chapter 4.1.1.4.1 of the Multisale EIS. Three general types of drilling muds have been used during drilling operations: water-based drilling muds (WBM or WBF); oil-based drilling muds (OBM or OBF); and synthetic-based drilling muds (SBM or SBF). Accidental releases of drilling fluids would have similar effects as discharges. In general, Continental Shelf Associates, Inc.'s research has shown that drilling mud discharges do not move very far even when discharged at the surface (CSA, 2006a); therefore, accidental releases of drilling muds are not expected to move very far either. The WBM's may be discharged, but those discharges are regulated by the USEPA through NPDES permits. The WBM's that are discharged increase turbidity in the water column and alter the sediment characteristics in the area where they settle (Neff, 2005). The OBM's are used to improve drilling through difficult geologic formations. The base mud for OBM is typically diesel or mineral oil. Because these oils often contain toxic materials such as PAH's, the discharge of OBM or cuttings wetted with OBM is prohibited. Thus, an accidental release of OBM's could decrease water quality locally. The SBM's were developed as an alternative to OBM and, thus, the use of OBM's has been decreasing. The base fluid is a synthetic material, typically an olefin or ester, free of toxic PAH's. Discharge of SBM itself is prohibited and, due to cost, is generally recycled (USEPA, 2009a). However, SBM-wetted cuttings may be discharged after the majority of the SBM has been removed. The SBF-wetted cuttings do not disperse as readily in water and descend in clumps to the seafloor (Neff et al., 2000). The SBF on the wetted cuttings gradually breaks down and may deplete the oxygen level at the sediment water interface as it degrades (Neff et al., 2000). An accidental release of SBF is expected to behave similarly with the SBF sinking to the seafloor adjacent to the release site and resulting in local anoxic conditions.

Pipeline Failures

A pipeline failure would result in the release of crude oil, condensate, or natural gas, the impacts of which are discussed above. Pipeline failures are discussed in more detail in **Chapter 3.2.3**.

Fuel Oil Spills from Collisions

A collision may result in the spillage of crude oil, refined products such as diesel, or chemicals. Crude oil and chemicals are discussed in the preceding paragraphs. Diesel is the type of refined hydrocarbon spilled most frequently as the result of a collision. Minimal impacts result from a spill since diesel is light and will evaporate and biodegrade within a few days (USDOC, NOAA, 2006). A collision could result in the release of up to the entire contents of the fuel tanks. Since collisions occur infrequently (USDOI, BOEMRE, 2010i), the potential impacts to offshore water quality are not expected to be significant.

Loss of Well Control

A loss of well control is the uncontrolled flow of a reservoir fluid that may result in the release of gas, condensate, oil, drilling fluids, sand, or water. The impacts of the release of gas, condensate, oil, and drilling fluids are discussed above. A loss of well control includes events with no surface expression or impact on water quality and events with a release of oil or drilling fluids. A loss of well control event may also result in localized suspension of sediments, thus affecting water quality temporarily. Loss of well control is a broad term that includes very minor well-control incidents up to the most serious well-control incidents (**Appendix B**). Historically, most losses of well control have occurred during

development drilling operations, but losses of well control can happen during exploratory drilling, production, well completions, or workover operations. Blowouts are a loss of well subset of more serious incidents, with a greater risk of oil spill or human injury. It is through the loss of well control that the volume and duration of a catastrophic oil spill could occur. Although there is an extremely low probability of a catastrophic spill event, the impacts of such an event on water quality are addressed in **Appendix B**. Overall, since loss of well control events and blowouts are rare events (USDOI, BOEMRE, 2010i) and of short duration, potential impacts to offshore water quality are not expected to be significant except in the rare case of a catastrophic event.

Summary and Conclusion

Accidental events associated with the CPA proposed action that could impact offshore water quality include spills of oil and refined hydrocarbons, releases of natural gas and condensate, spills of chemicals or drilling fluids, and loss of well control, pipeline failures, collisions, or other malfunctions that would result in such spills. Spills from collisions are not expected to be significant because collisions occur infrequently. Overall, loss of well control events and blowouts are rare events and of short duration, so potential impacts to offshore water quality are not expected to be significant except in the rare case of a catastrophic event. Although response efforts may decrease the amount of oil in the environment, the response efforts may also impact the environment. Natural physical, chemical, and biological processes would decrease the amount of spilled oil over time through dilution, weathering, and degradation of the oil (NRC, 2003). Chemicals used in the oil and gas industry are not a significant risk for a spill because they are either nontoxic, used in minor quantities, or are only used on a noncontinuous basis. Although there is the potential for accidental events, the CPA proposed action would not significantly change the water quality of the Gulf of Mexico over a large spatial or temporal scale.

4.1.1.2.2.4. Cumulative Impacts

A detailed description of cumulative impacts upon water quality can be found in Chapter 4.5.2 of the Multisale EIS and in Chapter 4.1.2.1.4 of the 2009-2012 Supplemental EIS.

Activities in the cumulative scenario that could impact offshore water quality generally include the broad categories of the proposed action and the OCS Program, the activities of other Federal agencies (including the military), natural events or processes, State oil and gas activity, and activities related to the direct or indirect use of land and waterways by the human population (e.g., urbanization, agricultural practices, coastal industry, and municipal wastes). Although some of these impacts are likely to affect coastal areas to a greater degree, coastal pollutants that are transported away from shore would still affect offshore environments. Many of these categories noted above would have some of the same specific impacts (e.g., vessel traffic would occur for all of these categories listed above except natural processes).

Sediment disturbance and turbidity may result from pipeline installation, installation and removal of platforms, discharges of muds and cuttings from drilling operations, disposal of dredge materials, sand borrowing, sediment deposition from rivers, and hurricanes. Turbidity is also influenced by the season. In offshore waters, these impacts may be the result of Gulfwide, OCS-related activities by other Federal agencies, including the military, and natural processes. State oil and gas activities may have some effect if they take place near offshore waters. Dredging projects related to restoration or flood prevention measures may be directed by the Federal Government for the benefit of growing coastal populations. These impacts generally degrade water quality locally and are not expected to last for long time periods. Furthermore, discharges from drilling platforms are regulated by USEPA through the NPDES permit process; thus, effects from these discharges should be limited.

Vessel discharges can degrade water quality. Vessels may be service vessels supporting the proposed action, OCS-related activities, or State oil and gas activities. However, the vessels may also be vessels used for shipping, fishing, military activities, or recreational boating. State oil and gas activities, fishing, and recreational boating would have fewer effects on offshore waters except for larger fishing operations and cruise lines, as smaller vessels tend to remain near shore. Fortunately, for many types of vessels, most discharges are treated or otherwise managed prior to release through regulations administered by USCG and/or USEPA, and many regulations are becoming more stringent. For example, the USCG Ballast Water Management Program, which was designed to prevent the introduction of invasive species, became mandatory for some vessels in 2004 (33 CFR 151 Subparts C and D) (U.S. Dept. of Homeland

Security, CG, 2010b). Furthermore, USCG published the Ballast Water Discharge Standard Notice of Proposed Rulemaking in the *Federal Register* on August 28, 2009. Additionally, the final Vessel General Permit, issued by USEPA, became effective on December 19, 2008. This permit is in addition to already existing NPDES permit requirements and now increases the NPDES regulations so that discharges incidental to the normal operation of vessels operating as a means of transportation are no longer excluded unless exempted from NPDES permitting by Congressional legislation (USEPA, 2008b). These regulations should minimize the cumulative impacts of vessel activities.

Erosion and runoff from point and nonpoint sources degrade water quality. Nonpoint-source runoff from onshore support facilities could result from OCS-related activities as well as State oil and gas activities and other industries and coastal development. Although offshore waters would not be affected as strongly as coastal waters since contaminants would be more diluted by the time they reached offshore areas, in many cases this runoff would still contribute somewhat to the degradation of offshore waters. Urban runoff can include suspended solids, heavy metals and pesticides, oil and grease, and nutrients. Urban runoff increases with population growth, and the Gulf Coast region has experienced a 103 percent population growth since 1970 (USDOC, NOAA, 2008a). The National Research Council (2003, Table I-4, p. 237) estimated that, on average, approximately 26,324 bbl of oil per year entered Gulf waters from petrochemical and oil refinery industries in Louisiana and Texas. Chapter 4.1.3.4 of the Multisale EIS discussed the various sources of petroleum hydrocarbons that can enter the Gulf of Mexico in further detail. The natural emptying of rivers into the GOM as part of the water cycle may introduce chemical and physical factors that alter the condition of the natural water through both natural and anthropogenic sources, such as the addition of waterborne pollutants, or the addition of warmer water, into the GOM through waterbodies emptying into the GOM, runoff, groundwater discharge, or precipitation. The Mississippi River introduced approximately 3,680,938 bbl of oil and grease per year from land-based sources (NRC, 2003, Table I-9, p. 242) into the waters of the Gulf. Nutrients carried in waters of the Mississippi River contribute to seasonal formation of the hypoxic zone on the Louisiana-Texas shelf. Recently, USEPA has proposed the first set of nutrient standards; the first set of standards is for the State of Florida (USEPA, 2010i). The proposed new water quality standards would set a series of numeric nutrient (nitrogen and phosphorus) limitations for Florida's lakes, rivers, steams, springs, and canals. The USEPA also regulates point-source discharges. Chapter 4.5.2.1 of the Multisale EIS summarizes the regulatory programs designed to protect the waters that enter the Gulf. If these and other water quality programs and regulations continue to be administered and enforced, it is not expected that additional oil and gas activities would adversely impact the overall water quality of the region.

Offshore waters, especially deeper waters, are more directly affected by natural seeps since the natural seeps in the Gulf of Mexico are located in offshore waters. Natural seeps are the result of natural processes. Hydrocarbons enter the Gulf of Mexico through natural seeps in the Gulf of Mexico at a rate of approximately 980,392 bbl per year (a range of approximately 560,224-1,400,560 bbl per year) (NRC, 2003, p. 191). Hydrocarbons from natural seeps are considered to be the highest contributor of petroleum hydrocarbons to the marine environment (NRC, 2003, p. 33). However, studies have shown that benthic communities are often acclimated to these seeps and may even utilize them to some degree (NRC, 2003, references therein and p. 33).

Discharges from exploration and production activities can degrade water quality in offshore waters. The USEPA regulates discharges associated with offshore oil and gas exploration, development, and production activities on the OCS under the Clean Water Act's NPDES program. Regulated wastes include drilling fluids, drill cuttings, deck drainage, produced water, produced sand, well treatment fluids, well completion fluids, well workover fluids, sanitary wastes, domestic wastes, and miscellaneous wastes (USEPA, 2009a). The bulk of waste materials produced by offshore oil and gas activities are produced water (formation water) and drilling muds and cuttings. Produced water is the largest waste stream by volume from the oil and gas industry that enters Gulf waters. The NRC has estimated the quantity of oil in produced water entering the Gulf per year to be 473,000 bbl (NRC, 2003, p. 200, Table D-8). The numbers in this paragraph were generated from converting the units reported in the noted reference and do not imply any level of significance. However, produced water is commonly treated to separate free oil and, as noted above, is a regulated discharge. Since discharges from drilling and production platforms are regulated by USEPA through the NPDES permit process, the effects from these discharges should be limited.

Since the marine environment is a dynamic system, sediment quality and water quality can affect each other. For example, a contaminant may react with the mineral particles in the sediment and be removed from the water column (e.g., adsorption). Thus, under appropriate conditions, sediments can serve as sinks for contaminants such as metals, nutrients, or organic compounds. However, if sediments are (re)suspended (e.g., due to a storm event), the resuspension can lead to a temporary redox flux, including a localized and temporal release of any formally sorbed metals as well as nutrient recycling (Caetano et al., 2003; Fanning et al., 1982).

Accidental releases of oil, gas, or chemicals would degrade water quality during and after the spill until either the spill is cleaned up or natural processes degrade or disperse the spill. These accidental releases could be a result of the proposed action, ongoing OCS activity, State oil and gas activity, the transport of commodities to ports, and/or coastal industries. Actions taking place directly in offshore waters would generally have more significant impacts on offshore waters. The impacts of rare, catastrophic spills are discussed in **Appendix B**. The extent of impact from a spill depends on the behavior and fate of oil in the water column (e.g., the movement of oil and the rate and nature of weathering), which, in turn, depends on oceanographic and meteorological conditions at the time (Appendix A.2 and A.3 of the Multisale EIS). Chapter 4.5.2.1 of the Multisale EIS contains more information on accidental releases. A major hurricane can result in a greater number of spill events, with increased spill volume and decreases in oil-spill-response times. In the case of an accidental event, it is likely that response efforts would reduce the amount of oil. See **Chapter 3.2.1.5** for further discussion of oil-spill-response considerations. Offshore water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts. Increased vessel traffic and the addition of dispersants and methanol to the marine environment in an effort to contain, mitigate, or clean up the oil may also tax the environment to some degree.

Summary and Conclusion

Water quality in offshore waters would be impacted by sediment disturbance and suspension (i.e., turbidity), vessel discharges, erosion and runoff of nonpoint-source pollutants including river inflows, natural seeps, discharges from exploration and production activities, and accidental events. These impacts may be a result of the proposed action and the OCS Program, the activities of other Federal agencies (including the military), private vessels, and natural events or processes. To a lesser degree, these impacts may also be a result of State oil and gas activity or activities or related to the direct or indirect use of land and waterways by the human population (e.g., urbanization, agricultural practices, coastal industry, and municipal wastes). Routine activities that increase turbidity and discharges are temporary in nature and are regulated; therefore, these activities would not have a lasting adverse impact on water quality. In the case of a large-scale spill event, degradation processes would decrease the amount of spilled oil over time through natural processes that can physically, chemically, and biologically degrade oil (NRC, 2003). The impacts resulting from the CPA proposed action are a small addition to the cumulative impacts on the offshore waters of the Gulf. The incremental contribution of the routine activities and accidental discharges associated with the proposed action to the cumulative impacts on offshore water quality is not expected to be significant as long as all regulations are followed.

4.1.1.3. Coastal Barrier Beaches and Associated Dunes

The BOEMRE has reexamined the analysis for coastal barrier beaches and associated dunes presented in the Multisale EIS and the 2009-2012 Supplemental EIS (addition of 181 South Area), based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for coastal barrier beaches and associated dunes presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Routine activities associated with the CPA proposed action, such as increased vessel traffic, maintenance dredging of navigation canals, and pipeline installation, would cause negligible impacts and would not deleteriously affect coastal barrier beaches and associated dunes. Indirect impacts from routine activities

are negligible and indistinguishable from direct impacts of onshore activities. The potential impacts from accidental events, primarily oil spills, associated with the CPA proposed action are anticipated to be minimal. The incremental contribution of the proposed action to the cumulative impacts to coastal barrier beaches and associated dunes is expected to be small.

4.1.1.3.1. Description of the Affected Environment

A detailed description of coastal barrier beaches and associated dunes in the Gulf of Mexico can be found in Chapter 3.2.1.1 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.3.1.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The coastal environments discussed here are those barrier beaches, wetlands, and submerged vegetation that might be impacted by activities resulting from the CPA proposed action. Geographically, the discussion covers coastal areas that range from the Texas/Louisiana border through Alabama. Several geologic subareas are found along this coast and they vary biologically. The environmental descriptions of this coast are organized into three geologic subareas: (1) the larger western portion of the Chenier Plain that extends into eastern Texas and western Louisiana (the western component of this feature has been previously discussed in **Chapter 4.1.1.3.1**); (2) the Mississippi River Delta complex of southeastern Louisiana; and (3) the barrier-island and Pleistocene Plain complex of Mississippi and Alabama. The landmasses in these areas are relatively low, so some form broad flat plains with gradually sloping topographies. Tides there are diurnal and micro-tidal. Tidal influences can be seen 25-40 mi (40-64 km) inland in some areas of Texas, Louisiana, and Alabama due to large bay complexes, channelization, and low topographies. Wind-driven tides are often dominant over the minimal gravity tides that occur there.

Since the last analysis and description of the CPA resources, there have been several major hurricanes in or near the CPA, as well as the DWH event, the largest oil spill ever recorded in the U.S. As a result of both of these factors, the existing condition of the barrier and beach resources has been altered. The descriptive narrative for these resources that follows reflects the post-storm and post-spill status of these resources. The general discussion of barrier island and beach formation discussed in Chapter 3.2.1.1 of the Multisale EIS and in Chapter 4.1.3.1.1 of the 2009-2012 Supplemental EIS can be applied to both the CPA and the WPA. This discussion focuses on which resources have experienced oil exposure and to what degree the resources were oiled. The information discussed is based on information from the Department of the Interior's Shoreline Cleanup Assessment Team (SCAT) maps and reports that are publicly available as of September 27, 2010; newspaper interviews; scientific magazines; and public, State, and Federal resource agency *Deepwater Horizon* oil-spill-response sites available on the Internet. Areas that have had oil exposure are identified, as these are part of the existing condition of the resource. No assumptions as to health of the resource are made here since monitoring and studies are ongoing. In **Chapter 4.1.1.3.3**, there is discussion based on past studies, current interviews with scientists participating in field studies, and observation teams on what types of possible effects the spill could have on these resources.

Chenier Plain

The Chenier Plain of eastern Texas and western Louisiana began developing about 2,800 years ago. During that period Mississippi River Delta sediments were intermittently eroded, reworked, and carried into the Chenier Plain area by storms and coastal currents. This deposition gathered huge volumes of mud and sand, and formed a shoreface that slopes very gently (almost imperceptibly) downward for a long distance offshore. This shallow mud bottom is viscous and elastic, which generates hydrodynamic friction (Bea et al., 1983). Hence, wave energies along the barrier shorelines of the Chenier Plain are greatly reduced and cause minimal longshore sediment transport along the Chenier Plain (USDOI, GS, 1988). More recently, this shoreline has been eroding as sea level rises. This process converts most of the coast to transgressive shorelines.

During periods when the course of the Mississippi River was at the western edge of its Deltaic Plain, sediments from the river were carried westward by currents along the shore. This formed mudflats along the Chenier Plain shoreline (Kemp, 1986). When the active river channel moved eastward and the

Chenier Plain lost most of its sediment supply, erosion reworked the mud deposits This winnowed out the finest materials and formed beachfront ridges (cheniers) along the coast, leaving remnants of the old mudflats (now marshes) behind them. The present topography reflects multiple river mouth ridges converging to form a single beachfront ridge between the river inlets (Gosselink et al., 1979). With the increase of flow this century in the Atchafalaya River close to the western edge of the delta, fluvial processes are again dominating the Chenier Plain, and mudflat development is occurring along its eastern coast (Kemp, 1986). Today, the Red River and about 30 percent of the Mississippi River are diverted to the Atchafalaya River. The diversions have increased the sediment load in the longshore currents that generally move slowly westward along the coast.

The barrier beaches of the Chenier Plain are generally narrow, low, and sediment starved due to the nature of coastal currents and the shoreface. Beach erosion has exposed relic marsh terraces that were buried by past overwash events. The Chenier Plain also supports an extensive marshland interspersed with large inland lakes formed in river valleys that were drowned after the last glaciation. When the sea reached its present level, the shoreline was more landward. Hurricane Rita (2005) severely impacted the shoreface and beach communities of Cameron Parish in southwest Louisiana. Some small towns in this area have no standing structures remaining. A storm surge approaching 6 m (20 ft) caused beach erosion and overwash, which flattened coastal dunes, depositing sand and debris well into the back marshes. After Rita, Hurricane Ike (2008) came ashore just west of the Texas/Louisiana border, severely impacting the eastern Chenier Plain near Cameron, Louisiana. A storm surge of 1-3 m (3-10 ft) overtopped the beach and severely impacted the Chenier Plain.

Coastal change includes both beach erosion and erosion of channels where water continues to flow seaward to the Gulf of Mexico (Doran et al., 2009). In addition to the hurricane effects, the shoreline of the Chenier Plain was exposed to dispersed oil from the DWH event. Based on the SCAT observation maps available as of September 20, 2010, that portion of the Louisiana coastline from the area east of the Chenier Plain to the Mississippi/Louisiana State boundary was exposed to oil. The shoreline was untouched from this point to just east of Rockefeller Wildlife Refuge and Game Preserve (LA State Highway 3147). Observations by the SCAT field observers noted no oil in these areas. Since there is no publicly available archival information on any changes to the Chenier Plain from oil exposure, it can only be reported that the areas were oiled but to varying degrees and for varying durations. The oiled sites are still under observation and the cleanup and monitoring operations are ongoing.

Mississippi River Delta Complex

The Mississippi Delta region comprises much of coastal Louisiana and adjacent Mississippi. It stretches from the Atchafalaya Bay to the Chandeleur Islands and includes the New Orleans metropolitan area. The Delta complex contains major river channels and levees, bayous, swamps, marshes, lakes, tidal flats and channels, barrier islands, and shallow sea environments. Most barrier shorelines of the Mississippi River Delta in Louisiana are transgressive and trace the seaward remains of a series of five abandoned deltas. As a lobe of the delta is abandoned by a shift in drainage, that portion begins to subside slowly into the sea and is further reduced by erosion. Some of the sediment may be reworked by wind and waves into barrier islands. The Chandeleur Islands and Grand Isle are an excellent example of this situation. Gradually woodland vegetation became established on the dune sands (e.g., oaks and oleander). Salty meadows, marshes, and lagoons occupy the lower terrain. Today, the Mississippi River is channelized through the Belize Delta, more commonly known as the Birdfoot Delta. Channelization isolated the river from most of this sixth delta, except near the distributary mouths. There, a small fraction of the river's sediment load is contributed to longshore currents for building and maintaining barrier shores. The bulk of river sediments are deposited in deep water, where they cannot be reworked and contribute to the longshore sediment drift. The shorefaces of the Mississippi River Delta complex slope gently seaward, which reduces wave energies at the shorelines. Mud flats are exposed during very low tidal events. This slope is not as shallow as that found off the Chenier Plain. The steepest shoreface of the delta is found at the Caminada-Moreau Coast, where the greatest rates of erosion occur. At this site, the longshore currents split to the east and west, which removes sand from the area without replenishment (Wolfe et al., 1988; Wetherell, 1992; Holder and Lugo-Fernandez, 1993).

Regressive shorelines do occur in Louisiana's deltaic region. The diversion at the Atchafalaya River has allowed the transport of large volumes of sediment into the shallow Atchafalaya Bay. There, inland

deltas are forming at the mouths of the Atchafalaya River and Wax Lake Outlet. Satellite photography of these deltas reveals that dredge-disposal islands were constructed off Point au Fer in shallow water (3-5 ft; 1-2 m) at the mouth of Atchafalaya Bay. If the Atchafalaya River Delta continues to build seaward as expected, these islands and the surrounding shallows would provide the foundations for a future barrier shoreline in this area.

Barrier island chains in the northern GOM extending from Atchafalaya Bay, Louisiana, to Mobile Bay, Alabama, are disintegrating rapidly as a result of combined physical processes involving sediment availability, sediment transport, and sea-level rise. The cumulative areas and rates of landloss from these ephemeral features are to some extent expected because present physical conditions are different from those that existed when the islands first formed. For example, during the past few thousand years sediment supply has diminished, rates of relative sea-level rise have increased, and hurricanes and winter storms have been frequent events that generate extremely energetic waves capable of permanently removing sediment from the islands. These processes continuously act in concert, increasing the rates of beach erosion and reducing the area of coastal land.

At greatest risk of further degradation are the barrier islands associated with the Mississippi Delta; these include the Chandeleur-Breton Island, Timbalier Island, and Isle Dernieres chains in Louisiana. These chains of individual transgressive barrier island segments have progressively diminished in size while migrating landward (McBride et al., 1992). Most of southeastern Louisiana's barrier beaches are composed of medium to coarse sand. Small shoreline regressions occur as a result of jetties located on the eastern end of Grand Isle, the western end of Caminada-Moreau Beach, the Empire navigational canal, and elsewhere in Louisiana. Most dune zones of the Mississippi River Delta contain low, single-line dune ridges that may be sparsely to heavily vegetated. Generally in this area, the vegetation on a dune ridge gets denser as the time between storms lengthens. Unfortunately, the past decade had an increase in tropical storm activity for the project area.

Hurricane Katrina (2005) caused severe erosion and landloss for the coastal barrier islands of the Deltaic Plain. The eye of Hurricane Katrina passed directly over the 50-mi (80-km) Chandeleur Island chain. Aerial surveys conducted by USGS on September 1, 2005, show that these islands were heavily damaged by the storm (USDOI, GS, 2005). The Chandeleur Islands were reduced by Hurricane Katrina from 5.64 mi^2 to 2.5 mi^2 and then to 2.0 mi^2 by Hurricane Rita (Di Silvestro, 2006). Grand Isle received extremely high winds and a 12- to 20-ft (3.5- to 6-m) storm surge that caused tremendous structural damage to most of its camps, homes, and businesses (Louisiana Sea Grant, 2006). Although barrier islands and shorelines have some capacity to regenerate over time, the process is very slow and often incomplete. With each passing storm, the size and resiliency of these areas can be diminished, especially when major storms occur within a short time period. Hurricane Katrina was the fifth hurricane to impact the Chandeleur Island chain within an 8-year period. The other storms were Hurricanes Georges (1998), Lili (2002), Ivan (2004), and Dennis (2005). Landmass rebuilt since Hurricane Ivan was subsequently washed away by Hurricane Katrina. Hurricanes Gustav and Ike (2008) reactivated ponds caused by the surge of Katrina. These ponds, some containing disturbance vegetation (Steyer et al., 2007), occurred in intermediate and fresh marshes located between Lake Lery and the Mississippi River. Surge impacts of Hurricane Gustav in the Deltaic Plain are smaller in scale and magnitude than surge impacts of Hurricane Ike in the Chenier Plain. The effects of Hurricane Gustav were also seen in the further erosion of the Chandeleur Islands, as well as significant erosion of the barrier islands forming the southern boundary of Terrebonne and Timbalier Bays (Barras, 2009). The Chandeleur Islands were reduced to 544.5 ha (1,345.5 ac), a reduction of 102.6 ha (253.5 ac) from the island's land area of 647.1 ha (1,599.0 ac) in 2006 (Barras, 2009). Following Hurricane Ike, significant surge-formed and surge-expanded ponds were not really noticeable east of Vermilion Bay (Barras, 2007a). Some new scours located on southeastern Marsh Island were originally scoured by Hurricane Lili on October 3, 2002 (Barras, 2007a). Water levels were visibly lower on the 2006 imagery of the Marsh Island area, causing the shallow scours to be classified as land in that dataset. Boyd and Penland (1988) estimated that storms raise mean water levels 1.73-2.03 m (5.68-6.66 ft) above mean sea level from 10 to 30 times per year. Under those conditions, barrier islands of the Mississippi River Delta complex experience severe overwash of up to 100 percent. Shell Key is a barrier feature that varies greatly from the others around the Delta. It is located south of Marsh Island, Louisiana, at the mouth of Atchafalaya Bay, and is composed almost entirely of oyster-shell fragments. It is found amid extensive shell reefs, which are part of the Shell Keys National Wildlife Refuge. This dynamic feature builds and wanes with passing storms. In 1992 and 1999, Hurricanes

Andrew and Francis reduced the island to little more than a shoal. The shallow, submerged shell reefs around Shell Key also serve as barrier features. Located on the other side of the bay's mouth and to the southeast, the Point au Fer Shell Reefs were commercially dredged for shells, and no longer exist (USDOI, FWS, 2001; Schales and Soileau, personal communication, 2001).

In addition to the hurricanes and winter storms, the Mississippi River Delta complex and its associated barrier islands were initially oiled as a result of the DWH event. Before the capping and permanent plugging of the well was complete, oil had reached the shorelines of the Chandeleur Islands, Whiskey Island, Raccoon Island, South Pass, East Fourchon/Elmers Island, Grand Isle, Trinity Island, and Brush Island (Cleveland, 2010). As of September 24, 2010, approximately 367 mi (591 km) of Louisiana's shoreline had some exposure to oil (USDOI, FWS, 2010a). Some areas were oiled more than once. The oiling ranged from light to heavy to occasional tarballs depending on the location and time. In most cases, the oil came ashore in lines perpendicular to the shoreline rather than in sheets. In an attempt to protect the Chandeleur Islands and the marshes shoreward of the islands from oil, the State of Louisiana constructed protective berms seaward of the islands. These berms are considered as part of the currently existing environment due to potential negative effects that this construction may have on the viability and sustainability of the protected island.

Mississippi and Alabama Coasts

The only factor that has a historical trend that coincides with the progressive increase in rates of landloss is the progressive reduction in sand supply associated with nearly simultaneous deepening of channels dredged across the outer bars of the three tidal inlets maintained for deep-draft shipping. Neither rates of relative sea-level rise nor storm parameters have long-term historical trends that match the increased rates of landloss since the mid-1800's. The historical rates of relative sea-level rise in the northern Gulf of Mexico have been relatively constant, and storm frequencies and intensities occur in multidecadal cycles. However, the most recent landloss accelerations are likely related to the increased storm activity since 1995. The cumulative areas and rates of landloss from these ephemeral features are to some extent expected because present physical conditions are different from those that existed when the islands first formed. For example, during the past few thousand years sediment supply has diminished, rates of relative sea-level rise have increased, and hurricanes and winter storms have been frequent events. These processes continuously act in concert, increasing rates of beach erosion and reducing the area of coastal land.

The Mississippi-Alabama barrier islands do not migrate landward as they decrease in size. Instead, the centers of most of the islands are migrating westward in the direction of the predominant littoral drift through processes of updrift erosion and downdrift deposition (Richmond, 1962; Otvos, 1970). Although the sand spits and shoals of the Mississippi-Alabama barriers are being transferred westward, the vegetated interior cores of the islands remain fixed in space. Rucker and Snowden (1989) measured the orientations of relict forested beach ridges on the Mississippi barriers and concluded that the ridges and swales were formed by recurved spit deposition at the western ends of the islands. The Dog Keys define the Mississippi Sound of Mississippi and Alabama. Mississippi has about 33.9 mi (54.6 km) of barrier beaches on these islands (USDOI, FWS, 1999). Dauphin Island represents about another 7 mi (12 km). This relatively young group of islands was formed 3,000-4,000 years ago as a result of shoal-bar accretion (Otvos, 1979). They are separated by wide passes with deep channels. Shoals are typically adjacent to these barriers. Generally, these islands are regressive and stable in size as they migrate westward in response to the predominantly westward-moving longshore currents. These islands generally have high beach ridges and prominent sand dunes. The islands are well vegetated among and behind the dunes and around ponds. Southern maritime climax forests of pine and palmetto are found behind some of their dune fields.

Dauphin Island, Alabama, is the exception to the above description. It is essentially a low-profile, transgressive barrier island, except for a small, eroding, Pleistocene core at its eastern end. The western end is a Holocene spit that is characterized by small dunes and many washover fans, exposed marsh deposits, and tree stumps exposed in the surf zone. Dauphin Island experienced significant shoreline retreat and rollover after Hurricane Katrina, with overwash deposits forming in the sound. Pelican Island, Alabama, is a vegetated sand shoal located Gulfward of Dauphin Island. Southeasterly of that island is Sand Island, which is little more than a shoal. These barrier islands are part of Mobile Bay's ebb-tidal

delta. As such, they continually change shape under storm and tidal pressures. Their sands generally move northwesterly into the longshore drift, nourishing beaches downdrift. These sediments can also move landward during flood tides (Hummell, 1990). The Gulf Shores region of Alabama extends from Mobile Point eastward to the Florida boundary, a distance of about 31 mi (50 km) (Smith, 1984). It has the widest beaches and largest dune system among the barrier beaches in the CPA.

Since the mid-1800's, average rates of landloss for all the Mississippi islands accelerated systematically. There is an inverse relationship between island size and percentage of land reduction for each barrier. For example, Horn Island lost 24 percent and Ship Island lost 64 percent of its area since the mid-1800's (Morton, 2008). Ship Island is particularly vulnerable to storm-driven landlosses because topographic and bathymetric boundary conditions focus wave energy onto the island. The three predominant morphodynamic processes associated with landloss are as follows: (1) unequal lateral transfer of sand related to greater updrift erosion compared with downdrift deposition; (2) barrier narrowing resulting from simultaneous erosion of the Gulf and soundside shores; and (3) barrier segmentation related to storm breaching. The western portion of Dauphin Island is migrating landward as a result of storms that erode the Gulf shore, overwash the island, and deposit sand in Mississippi Sound. This has caused a gain in land during the 20th century. Petit Bois, Horn, and Ship Islands have migrated westward as a result of predominant westward sediment transport by alongshore currents, and Cat Island is being reshaped as it adjusts to post-formation changes in wave and current patterns associated with deposition of the St. Bernard lobe of the Mississippi Delta (Morton, 2008).

The principal causes of barrier island landloss are frequent intense storms, a relative rise in sea level, and a deficit in the sediment budget. However, the most recent landloss accelerations are likely related to the increased storm activity since 1995. Although overwash channels do not commonly occur, the islands may be overwashed during strong storms, as was seen after Hurricanes Ivan (2004), Dennis (2005), and Katrina (2005). Hurricane Katrina's storm surge caused substantial beach erosion and, in some cases, completely devastated coastal areas. In Dauphin Island, approximately 90 mi (150 km) to the east of the point where the hurricane made landfall, the sand that comprised the barrier island was transported across the island into Mississippi Sound, pushing the island towards land.

Aside from the hurricane effects on the barrier island and beach resources, the DWH event exposed most of the Gulf Coast shoreline to some degree of oiling, i.e., from western Louisiana to the Florida panhandle. Based on the SCAT ground observation, the cumulative amount of shoreline oiled as of September 27, 2010, was 494 mi (795 km) (USDOI, FWS, 2010a). This cumulative figure of oiled shoreline includes shorelines of beaches and barrier islands that were exposed to oil, whether it was very light, light, moderate, heavily oiled, or only observations of tarballs. As of September 27, 2010, only 176 km (109 mi) of shoreline was considered moderately to heavily oiled, with 158 km (98 mi) in Louisiana, and 18 km (11 mi) in Florida. In Louisiana, the heavy to moderate oiling was sporadic along the shorelines of Grand Terre Island, Grand Isle, and Bay Batiste. By May 23, 2010, the Louisiana Department of Environmental Quality had confirmed shoreline impact on the Chandeleur Islands, Whiskey Island, Raccoon Island, South Pass, East Fourchon/Elmers Island, Grand Isle, Trinity Island, Brush Island, the Pass a Loutre area, and Marsh Island. On June 1, 2010, oil first appeared on Dauphin Island off the coast of Alabama near the mouth of Mobile Bay. Strands of oil about a 1 m (3 ft) wide and 2 mi (3 km) long were found on Petit Bois Island near the Mississippi-Alabama border (Cleveland, 2010). The shoreline in the Barataria Bay complex, along with the shorelines west of the Mississippi River Delta complex, received the most oil (Cleveland, 2010). Some of these areas may have been oiled several times. It must be noted that the SCAT maps do not indicate a continuous, uninterrupted area of oiled shoreline. Because these coastlines encountered some degree of oiling, oil is now part of the existing condition of the resource.

Deepwater Horizon Event Oil Exposure

In April 2010, the explosion of the DWH drilling platform resulted in the largest oil spill in the history of U.S. The spill was approximated at 4.9 million barrels; the well was capped on July 15, 2010, after oil flowed into the Gulf for 87 days. The drilling rig was located west of the Mississippi River approximately 90 mi (145 km) from the Louisiana coast. The bulk of the oil was off the coast of Louisiana, but eventually the oil spread east of the Mississippi River along the Mississippi, Alabama, and Florida coastlines as far away as Panama City, Florida. At the time of preparation of this Supplemental

EIS, there was little conclusive scientific information on the impacts of the spill. The available information presented here is primarily from accounts based on interviews with scientists or personnel with the USCG's Oil Spill Response Team at the Unified Command Post overseeing cleanup operations. Various wildlife and resource agencies have launched SCAT to locate the oil as it appears in order to engage cleanup teams. Other agencies are involved in the NRDA process that is collecting data to identify and quantify the impacts of the spill. To date, none of this information is publicly available; therefore, the information presented here only notes what resources have been contacted by the spilled oil based on the SCAT observation maps and data available from interviews of local scientists participating in the oil response effort.

4.1.1.3.2. Impacts of Routine Events

Background/Introduction

Impacts to the general vegetation and physical aspects of coastal environments by routine activities resulting from the CPA proposed action are considered in detail in Chapter 4.2.2.1.3.1 of the Multisale EIS and in Chapter 4.1.3.1.2 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared

This section considers impacts from routine activities associated with the CPA proposed action to the physical shape and structure of barrier beaches and associated dunes. The primary impact-producing routine activities associated with the proposed action that could affect these environments include pipeline emplacements, navigation channel use (vessel traffic) and dredging, and the use and construction of support infrastructure. As a result of the DWH event, remnant oil is still being found either in the water column or on the bottom in some areas (Cleveland, 2010). If the remnant oil is encountered, routine activities such as dredging or vessel traffic can potentially resuspend and transport it within the area. The oil is greatly weathered and treated, so it is expected to have low or no level of toxicity for interstitial beach inhabitants. The following sections describe the sources and types of these potential impacts.

Pipeline Emplacements

Where a pipeline crosses the shoreline is referred to as a pipeline landfall. Many OCS pipelines make landfall on Louisiana's barrier island and shorelines. Pipeline landfall sites on barrier islands could cause accelerated beach erosion and island breaching. The CPA proposed action does not include new pipelines that make landfall on barrier islands or mainland beaches. If more detailed site-specific, postlease analysis indicates barrier beach landfalls are necessary, modern techniques such as directional drilling would be used to bring the pipeline ashore. Studies have shown that little to no impact to barrier beaches results from modern techniques such as directional boring (LeBlanc, 1985; Mendelssohn and Hester, 1988; Wicker et al., 1989). Since 2002, only one new pipeline has come to shore in Louisiana from OCS-related activities. The 30-in Endymion Oil Pipeline, which delivers crude oil from South Pass Block 89 to the LOOP storage facility near the Clovelly Oil and Gas Field, was installed in 2003. Based on a review of the data in the COE permit application (No. 20-020-1632), the emplacement of the pipeline caused zero impacts to marshes (emergent wetlands) and beaches. This was because the operator used horizontal, directional (trenchless) drilling techniques to avoid damages to these sensitive habitats. Additionally, the pipeline route maximized an open-water route to the extent possible (a comprehensive description of current mitigation measures is discussed in **Chapter 2.2.2**). A comparison of aerial photos taken before and after Hurricanes Katrina and Rita reveal no observable landloss or impacts associated with the Endymion Oil Pipeline. Hurricane Gustav further eroded barrier beaches and completely degraded small islands such as Wine Island. Although Hurricane Gustav eroded some beaches and damaged onshore pipelines near Port Fourchon, offshore pipelines were left intact.

Vessel Traffic and Dredging

Vessel traffic that may support the proposed action is discussed in **Chapter 3.1.1.4** of this Supplemental EIS and in Chapter 4.1.1.8.4 of the Multisale EIS. Navigation channels projected to be

used in support of the proposed action are discussed in **Chapter 3.1.2** of this Supplemental EIS and in Chapter 4.1.2.1.9 of the Multisale EIS. Navigation channels that support the OCS Program are listed in Table 3-36 of the Multisale EIS. Current navigation channels will not change and no new navigation channels are required as a result of the proposed action.

Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in areas already affected by natural erosion processes. Much of the service-vessel traffic that is a necessary component of OCS activities uses the channels and canals along the Louisiana coast. Potential for resuspension and transport of oil from the DWH event exists as a result of heavy vessel traffic or dredging in areas previously oiled. As a result of the storm surge of Hurricane Gustav, the channel at Port Fourchon lost depth from siltation and displacement of some of the rock channel armor. This channel may require some minimal maintenance dredging.

Based on earlier studies by Johnson and Gosselink (1982), canal widening rates in coastal Louisiana range from about 2.58 m/yr (8.46 ft/yr) for canals with the greatest boat activity to 0.95 m/yr (3.12 ft/yr) for canals with minimal boat activity. A recent study entitled "Navigation Canal Bank Erosion in the Western and Central Gulf of Mexico" indicates that shoreline retreat rates along canals were highly variable within and across unarmored portions of the canals (Thatcher et al., 2011). It was noted that geology and vegetation type influenced the rate of shoreline change. The study also noted that the canal widening rate slowed to -0.99 m/yr (-3.25 ft/yr) for the 1996/1998-2005/2006 time period as compared with -1.71 m/yr (-5.61 ft/yr) 1978/1979-1996/1998 time period. The existing armored navigation channels (e.g., Port Fourchon) that are used to reach shore bases will minimize or eliminate the potential for shoreline erosion from vessel traffic. Widening rates for navigation canals have been reduced as a result of aggressive management and the restoration of canal edges to prevent erosion. An example of this is the construction of rock breakwaters along portions of some of these canals, as well as enforcing "wake zone" speeds (Johnston et al., 2009). In addition, BOEMRE and the USGS National Wetlands Resource Center have designed and funded a study that was reviewed and coordinated with the Louisiana Department of Environmental Quality to better understand salinity behavior in marshes adjacent to navigation canals (Snedden, in preparation). This 2-year study began in January 2010 and is scheduled for completion in December 2011.

Continued Use of Support Infrastructure

In the past, OCS-related facilities were built in the vicinity of barrier shorelines of the CPA. The use of some existing facilities in support of the CPA proposed action and subsequent lease sales in the CPA may extend the useful lives of those facilities. During that extended life, erosion-control structures may be installed to protect a facility. Although these measures may initially protect the facility as intended, such structures may accelerate erosion elsewhere in the vicinity. They may also cause the accumulation of sediments updrift of the structures. These sediments might have alleviated erosion downdrift of the structure. These induced erosion impacts would be most damaging locally. In deltaic Louisiana where the sediment supply is critically low, these impacts may be distributed much more broadly. These impacts will last as long as the interruption of the sediment drift continues, and that can continue after the structure is removed if the hydrodynamics of the area are permanently modified. Expansions of existing facilities located on barrier beaches or in associated dunes would cause loss and disturbance of additional habitat. Abandoned facility sites must be cleared in accordance with Federal, State, and local government, and landowner requirements. Materials and structures that would impair or divert sediment drift among the dunes and on the beach must be removed.

Proposed Action Analysis

Zero to one pipeline landfalls are projected as a result of the CPA proposed action, resulting in up to 2 km (1.2 mi) of onshore pipeline. Should one be constructed, it would most likely be in Louisiana, where the large majority of the infrastructure exists for receiving oil and gas from the CPA. No landfalls are presently planned for barrier or mainland beaches, but if it is later determined that such a landfall in the vicinity of a barrier beach and associated dunes is necessary, current regulatory procedures would be used to evaluate any impacts associated with the action. Wherever a landfall occurs, regulatory programs and permitting processes (COE and the Louisiana Dept. of Natural Resources) are sequenced to ensure wetlands are protected first through avoidance, then minimization of impacts, and finally compensation

for unavoidable impacts. The use of modern technologies (e.g., directional boring) greatly reduces and possibly eliminates impacts to coastal barrier islands and beaches. Therefore, effects on barrier beaches and dunes from pipeline laying activities associated with the CPA proposed action are expected to be minor or nonexistent. These impacts are considered to be negligible. Turner and Cahoon (1988) found that OCS traffic in general comprises a relatively small percentage (~12%) of the total commercial traffic using navigation channels. The average contribution of the CPA proposed action to OCS-related vessel traffic in navigation canals is expected to be small (2-3%). Erosion of coastal barrier beaches and associated dunes from vessel traffic associated with the CPA proposed action are expected to be negligible.

Adverse impacts from maintenance dredging of navigation channels can be mitigated by discharging dredged materials onto barrier beaches or strategically into longshore sediment currents downdrift of maintained channels, or by using the dredged material to create wetlands. Negative effects of sediment sinks created by jetties can be mitigated by reducing the jetty length to the minimum needed and by filling the updrift side of the jetty with appropriate sediment. Sediment traps that are created by unnecessarily large bar channels can also be mitigated by reassessing the navigational needs of the port and by appropriately reducing the depth of the channel. Mitigating adverse impacts should be addressed in accordance with requirements set forth by the appropriate Federal and State permitting agencies. Effects on coastal barrier beaches and associated dunes associated with dredging from the CPA proposed action are expected to be restricted to minor and localized areas downdrift of the channel. There are 0-1 gas processing plants projected to be constructed as a result of the CPA proposed action. Should one be constructed, it would most likely be in Louisiana. Wherever a landfall occurs, regulatory programs and permitting processes of COE and the Louisiana Dept. of Natural Resources are sequenced to ensure wetlands are protected. Effects on coastal barrier beaches and associated dunes associated with construction of a gas processing plant from the CPA proposed action are expected to be restricted to minor and very localized areas downdrift of the channel.

Summary and Conclusion

Effects to coastal barrier beaches and associated dunes from pipeline emplacements, navigation channel use and dredging, and construction or continued use of infrastructure in support of the CPA proposed action are expected to be restricted to temporary and localized disturbances. The 0-1 pipeline landfalls projected in support of the proposed action are not expected to cause significant impacts to barrier beaches because of the use of nonintrusive installation methods and regulations. New processing plants would not be expected to be constructed on barrier beaches. The proposed action may contribute to the continued use of existing facilities, which can add to erosion.

Maintenance dredging of barrier inlets and bar channels is expected to occur, which combined with channel jetties, causes minor and localized impacts on adjacent barrier beaches. This is due to permit regulations and mitigation efforts. The worst of these situations is found on the sediment-starved coasts of Louisiana, where sediments are largely organic. Because these impacts occur whether the proposed action is implemented or not, the proposed action would account for a small percentage of these impacts.

In conclusion, the CPA proposed action is not expected to adversely alter barrier beach configurations significantly beyond existing, ongoing impacts in localized areas. Strategic placement of dredged material from channel maintenance, channel deepening, and related actions can mitigate adverse impacts upon those localized areas.

4.1.1.3.3. Impacts of Accidental Events

Background/Introduction

Impacts to the general vegetation and physical aspects of coastal environments by oil spills and cleanup response activities resulting from the CPA proposed action are considered in Chapter 4.4.3.1 of the Multisale EIS and in Chapter 4.1.2.13 of the 2009-2012 Supplemental EIS.

The types and sources of spills that may occur and their characteristics are described in Chapter 4.3.1 of the Multisale EIS and in **Chapter 3.2** of this Supplemental EIS. There is also a risk analysis of accidental events in **Chapter 3.2.1**. Figures 4-13 and 4-14 of the Multisale EIS provide the probability of an offshore spill ≥1,000 bbl occurring and contacting counties and parishes around the Gulf. Potential

impacts from oil spills to barrier islands seaward of the barrier-dune system are considered in this section, while potential impacts to barrier islands landward of the barrier-dune system are considered in the wetlands analysis (**Chapter 4.1.1.4.3**). Impacts to biological, recreational, and archaeological resources associated with beach and dune environments are described in the impact analysis sections for those specific resources.

The central Gulf Coast (i.e., Louisiana, Mississippi, Alabama, and western Florida) and the associated barrier islands and beaches have experienced an increase in frequency of high-intensity hurricanes and tropical storms over the past several years. As a result of four powerful hurricanes (i.e., Hurricanes Katrina, Rita, Gustav, and Ike), changes in barrier island topography and decreases in beach elevation potentially increased the probability for oiling farther up the beach head in some locations. Due to the more gentle slopes, removal of beach ridges, and cuts into the mainland barrier beaches, the remnant transition zone between the water and the current beach ridge may be more vulnerable to spills. In some areas along the Louisiana coast, barrier islands were severely damaged, resulting in either heavily degraded beachfront elevations and ridges or submergence of the island from sediments redistributed by the storm surge. In coastal Louisiana, dune-line heights have been drastically reduced by the storm activity. The Isle Dernieres and Chandeleur Island chains had losses in elevation and beach erosion. In Mississippi and Alabama, dune elevations exceed those in Louisiana but have been reduced to some extent due to storm activity. Hurricane Katrina completely inundated the western side of Dauphin Island, Alabama, decreasing elevations to less than 2 m (7 ft). Hurricane Gustav then completely overwashed the western edge of the island, resulting in large changes to the islands' shape and topography (USDOI, GS, 2008). For tides to carry oil from a spill across and over the dunes, strong southerly winds would have to persist for an extended time prior to or immediately after a spill. Strong winds required to produce such high tides would also accelerate dispersal and spreading of the oil slick, thereby reducing impact severity at the landfall site. Significant dune contact by a normal spill associated with the proposed action is not likely; however, the reduced degree of protection does make the mainland beaches and habitat on the back side of the barrier islands more susceptible to oiling than they were under pre-storm if winds bring the oil shoreward.

Aside from the hurricane effects on the barrier islands and beach resources, the DWH event exposed most of the Gulf Coast shoreline from western Louisiana to the Florida panhandle to some degree of oiling. Based on the SCAT ground observation, the cumulative amount of shoreline oiled as of September 27, 2010, was 795 km (494 mi) (USDOI, FWS, 2010a). The cumulative figure of oiled shorelines includes beaches and barrier island associated shorelines that were exposed to oil, be it very light, light, moderate, heavily oiled, or tarballs. Moderately to heavily oiled shorelines were 176 km (109 mi) for the GOM with 157 km (98 mi) in Louisiana, 14 km (9 mi) in Mississippi, and 3 km (2 mi) in Florida.

The amount of shoreline oiled changes daily based on the observations of SCAT. In Louisiana, the heavy to moderate oiling was sporadic along the shorelines of Grand Terre, Grand Isle, and Bay Batiste.

By May 23, 2010, the Louisiana Department of Environmental Quality confirmed shoreline impact on the Chandelier Islands, Whiskey Island, Raccoon Island, South Pass, East Fourchon/Elmers Island, Grand Isle, Trinity Island, Brush Island, the Pass a Loutre area, and Marsh Island. On June 1, 2010, oil first appeared on Dauphin Island, and strands of oil (1 m x 3 km; 3 ft x 2 mi) were found on Petit Bois Island near the Mississippi/Alabama border (Cleveland, 2010). The shoreline in the Barataria Bay complex as well as the shorelines west of the Mississippi Delta complex received the most oil (Cleveland, 2010). Although it is known where oil was observed onshore, these oiling estimates do not reflect a continuous, uninterrupted area of oiled shoreline.

A large amount of dispersants was used offshore at or near the well site, and oil was kept offshore by booms and skimming for long periods of time. These mitigating factors, combined with the natural weathering of the oil, should greatly reduce the toxicity of the incoming oil from offshore. After NRDA releases the data concerning the condition of the incoming oil, long-term and local effects of the oil on the shoreline can be discussed in more detail.

Proposed Action Analysis

Barrier islands and beaches adjacent to the CPA are restricted to the coastal waters of Louisiana, Mississippi, Alabama, and eastern Florida. The greatest threat to the barrier island and beach resources

would be from inland oil spills. Based on the assumption that spill occurrence is proportional to the volume of oil handled, sensitive coastal environments in eastern Louisiana from Atchafalaya Bay to east of the Mississippi River (including Barataria Bay) have the greatest risk of contact from spills related to the CPA proposed action. Approximately 49-126 spills are estimated to occur within Gulf coastal waters from activities supporting the CPA proposed action over the 40-year life of the lease sale. Most (about 90%) of these spills would be ≤1 bbl. The most likely locations of the estimated 44-114 coastal spills <1 bbl would be proximate to the major oil pipeline or shore facilities (**Table 3-7**). The greatest risk of contact would be from the assumed 3,000-bbl spill should it occur within or near wetlands. The incremental increase in oil production from this lease sale is not expected to result in an overall increase in the number of oil spills ≥1,000 bbl likely to occur as a result of the CPA proposed action. Activity that would result from the addition of this lease sale would cause a negligible increase in the risk of a large spill occurring and contacting barrier islands and beaches. If oil should reach the beaches from this distance, it would be sufficiently weathered and detoxified through biodegradation, mixing, and the weathering process.

The probabilities of an offshore spill ≥1,000 bbl occurring and contacting environmental features are described in Chapter 4.3.1.8 of the Multisale EIS. Eight parishes in Louisiana have a chance of spill to contact their shores. For these parishes, the chance of an OCS offshore spill ≥1,000 bbl ranges from 1 to 15 percent. Generally, the coastal, deltaic parishes of Louisiana have the highest risk of being contacted by an offshore spill from the CPA proposed action. Plaquemines Parish has the highest probability at 10-15 percent (Chapter 4.3.1.8 of the Multisale EIS). For offshore spills <1,000 bbl, only those >50 bbl would be expected to have a chance of persisting as a cohesive slick long enough for the slick to reach land. Few offshore spills of 50-1,000 bbl are estimated to occur as a result of the proposed action, and a few of these slicks are expected to occur proximate to State waters and to reach shore. Should a slick from such a spill make landfall, the volume of oil remaining in the slick is expected to be small.

Sensitive coastal environments in eastern Louisiana, from Atchafalaya Bay to east of the Mississippi River, including Barataria Bay, have the greatest risk of being contacted by spills from operations related to the CPA proposed action. Should a spill contact a barrier beach, oiling is expected to be light and sand removal during cleanup activities minimized. No significant impacts to the physical shape and structure of barrier beaches and associated dunes are expected to occur as a result of the CPA proposed action.

Although the probability of a catastrophic spill such as the DWH event is low, the potential impacts of such a spill is discussed in **Appendix B** to the extent possible with the current data available.

Oil-Spill Impacts

The results of earlier studies done in Texas (Webb, 1988) utilizing oiled and unoiled sands indicated the survival of dune transplants was better for both species of plants tested in the oil-contaminated dune than the oil-free dune. It was concluded that common dune plants can colonize or can be transplanted successfully into oil-contaminated sands. The explanation of the favorable survival is probably due to the weathering from the photo-oxidation, volatilization, and biodegradation of the oil. However; test results of the oiled sands indicated that, while lighter toxic alkanes and cycloalkanes were absent in the "oiled sands," 21 percent of the crude oil was water-insoluble PAH's. Analysis of the weathered crude oil did not indicate a high percentage of PAH's. The study concluded that the weathering process removed most of the toxic compounds (Webb, 1988).

There are various factors and conditions that affect the toxicity and severity of oil spills on the barrier island systems and the associated vegetation. The two most important variables involve location (distance of spill from landfall) and weather. If the there is sufficient distance and proper weather conditions between the spill and landfall, the spill can be dispersed and thinned. This would allow for optimal conditions for biodegradation, volatilization, and photo-oxidation. Therefore, due to the distance from shore, the weather, the time oil remains offshore, and the dispersant use, offshore-based crude oil would be less in toxicity when it reaches the coastal environments.

Inland spills have the greatest potential for affecting the coastal barrier resources due to their proximity to the resources. Inland spills result from damage to pipelines, vessel collisions, malfunctions of onshore production or storage facilities; and blowouts have the greatest potential for contacting the barrier and mainland beach resources. The effects from these oil spills depends on the geographic location, volume, and rate of the spill; type of oil; oil-slick characteristics; oceanic conditions and season

at the time of the spill; and response and cleanup efforts. Inland spills from offshore coastal waters and in the vicinity of Gulf tidal inlets present a greater potential risk to barrier beaches and dunes because of their close proximity, but inland spills occurring away from Gulf tidal inlets are not expected to significantly impact barrier beaches and dunes.

No significant impacts to the physical shape and structure of barrier beaches and associated dunes are expected to occur as a result of accidental events associated with the CPA proposed action. However, as a result of the DWH event, the State of Louisiana has partially constructed an oil mitigation berm seaward of the Chandeleur Islands. Theoretically, it is to protect the island and inland marshes from incoming oil. The Federal resource agencies (NMFS, FWS, and USEPA), as well as the local scientific community, is concerned that the berm may cause further erosion of the island because of changes to hydrology and topography (Lavioe et al., 2010). In addition, the use of heavy equipment for shaping the berm material and the chance of disturbing pipelines in the borrow areas could cause potential indirect impacts to the coast.

Through the cleanup effort, associated foot traffic may work oil farther into the sediment than would otherwise occur. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. Mainland beaches in Louisiana (Grand Isle and Grand Terre), Mississippi (Waveland, Biloxi, and Gulfport), Alabama (Perdido and Gulf Shores), and Florida (Santa Rosa, Pensacola, and Eglin) are currently undergoing either manual or mechanical cleanup primarily for tarballs or some submerged weathered oil mats. Mechanical, tractor-mounted sifters disrupt the sand base, cause compaction, and disturb the nontidal beach habitat. Should a spill contact a barrier beach, oiling is expected to be light and sand removal during cleanup activities minimized.

Summary and Conclusion

Because of the proximity of inshore spills to barrier islands and beaches, inshore spills pose the greatest threat. Such spills may result from either vessel collisions that release fuel and lubricants or from pipelines that rupture. Impacts of a nearshore spill would be considered short term in duration and minor in scope because the size of such a spill is projected to be small (coastal spills are assumed to be 5 bbl; Table 4-13 of the Multisale EIS). Offshore-based crude oil would be less in toxicity when it reaches the coastal environments. This is due to the distance from shore, the weather, the time oil remains offshore, and the dispersant used. Equipment and personnel used in cleanup efforts can generate the greatest direct impacts to the area. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts.

The BOEMRE has reexamined the analysis for coastal barrier beaches and associated dunes presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. Although the most current information did reveal that some of the barrier islands had experienced storm-induced reductions in beach shoreline elevations and erosion, the significance of this loss of protection is small in comparison with the overriding climatic forces (USDOC, NMFS, 2007a). Therefore, this information would not alter the overall conclusion that impacts on barrier islands and beaches from accidental impacts associated with the CPA proposed action would be minimal. Should a spill other than a catastrophic spill contact a barrier beach, oiling is expected to be light and sand removal during cleanup activities minimized. No significant long-term impacts to the physical shape and structure of barrier beaches and associated dunes are expected to occur as a result of the CPA proposed action. The current lease sale would not pose a significant increase in risk to barrier island or beach resources.

4.1.1.3.4. Cumulative Impacts

A detailed description of cumulative impacts upon coastal barrier beaches and associated dunes can be found in Chapter 4.5.3.1 of the Multisale EIS and in Chapter 4.1.3.1.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Background/Introduction

This cumulative analysis considers the effects of impact-producing factors related to the proposed action, prior and future OCS sales in the Gulf of Mexico, State oil and gas activities, other governmental and private projects and activities, and pertinent natural processes that may affect barrier beaches and dunes. Specific impact-producing factors considered in this cumulative analysis include channelization of the Mississippi River, beach protection and stabilization projects, natural processes, navigation channels, development and urbanization, oil spills, oil-spill response and cleanup activities, pipeline landfalls, potential for nearshore salinity modifications (preparation of salt domes for oil storage), tourism, and recreational activities.

River Channelization and Beach Protection

Channel deepening and widening along the Mississippi River and other major coastal rivers, in combination with channel training and bank stabilization work, has resulted in the reduced delivery of sediment to the eroding deltas along the mouths of the rivers. This reduction in sediment not only impedes delta building, but it also fails to provide the needed sediment transport required for nourishment of the eroding offshore barrier islands and their beaches. This, coupled with beach building and stabilization projects utilizing mined sands, jetties, groins, and other means of sediment capture, is depriving natural restoration of the barrier beaches normally accomplished through sediment nourishment and sediment transport.

Subsidence, erosion, and dredging of inland coastal areas, with the concurrent expansion of tidal influences that are particularly as seen in Louisiana, continually increases tidal prisms around the Gulf. These changes may result in the opening and deepening of many new tidal channels that connect to the Gulf and inland waterbodies. These incremental changes would cause adverse impacts to barrier beaches and dunes. Efforts to stabilize the Gulf shoreline have adversely impacted barrier landscapes in Louisiana. Large numbers and varieties of stabilization techniques including groins, jetties, seawalls, and artificially maintained channels and jetties that were installed to stabilize navigation channels have been applied along the Gulf Coast. These efforts have contributed to coastal erosion by depriving downdrift beaches of sediments and by increasing or redirecting the erosional energy of waves (Morton, 1982). Over the last 20 years, better dune and beach stabilization has been accomplished by using more natural applications such as sand dunes, beach nourishment, and vegetative plantings.

As a result of the DWH event, protective berms are being constructed seaward of barrier islands (Chandeleur Islands) to protect the inland marshes, wetlands, and seagrasses from incoming oil associated with this large spill. The effects of this berm construction on barrier islands could alter present sediment transport needed for barrier island growth, as well as change inlet velocities and hydrology in such a way that accelerated erosion of Chandeleur Island could occur (Lavoie et al., 2010). Aside from the construction impacts, the amount of mined sand required would continue to reduce the already scarce supply of sand needed for both natural barrier island building and future coastal restoration projects. Other potential cumulative and continuing impacts from this berm construction can be measured through long-term monitoring. These impacts include the fate of oil that may be sequestered in the mined sands, and the effects of their long-term release. The current testing of dredged sediments required under the COE dredging permit for the berm construction does not indicate the presence of petroleum-based toxicants at this time. The potential exists for anoxic conditions in deep holes where the sand is mined, but COE permit requirements establish that the underwater borrow sites should be backfilled or shallowed to the greatest extent possible.

Natural Processes

Barrier beaches along coastal Louisiana have experienced severe erosion and landward retreat (marine transgression) because of natural processes enhanced by human activities. Adverse effects on barrier beaches and dunes have resulted from changes to the natural dynamics of water and sediment flow along the coast. This can happen in an attempt to control catastrophic floods and change the natural environment to better accommodate navigation on waterways used to support OCS and non-OCS seaborne traffic. Sea-level rise and coastal subsidence with tropical and extra-tropical storms exacerbate

and accelerate the erosion of coastal barrier beaches along the Gulf Coast of Louisiana. The western edge of the CPA coast received major damage as a result of Hurricanes Katrina, Rita, Gustav, and Ike.

The passage of these four powerful hurricanes within a 4-year period resulted in changes in barrier island topography and lowered beach elevation. These changes could potentially increase the probability for beach oiling farther up the beach in some locations. Due to the now more gentle slopes and in some cases cuts into the mainland barrier beaches left by the storms, more of the transition zone between the water and beach ridge may be more vulnerable to spills. In some areas along the Louisiana coast, barrier islands were severely damaged either by heavily degrading beachfront elevations and beach ridges or by completely overtopping the islands. This surge over the island resulted in either removing or completely redistributing the sediments on the island, so the island becomes submerged. Along the Mississippi/Alabama coast, barrier islands (e.g., Gulf Islands National Seashore chain and Dauphin Island) were further eroded and inlets widened by the series of storms following Hurricanes Katrina and Rita. The widening of inlets initiated by Katrina and Rita provided larger pathways for saltwater and oil influx into the island wetlands. Grand Isle, Louisiana, and its beach restoration project were severely damaged by Hurricanes Katrina and Gustav. These islands received oil on the beaches from the DWH event.

Hurricane Rita in September 2005 severely impacted the shore face and beach communities of Cameron Parish in southwest Louisiana. These barriers lost elevation and vegetative cover as a result of the erosion forces accompanying the storm surge and scour from storm-driven debris (Barras, 2007b). This removal of vegetative cover and scour scars provides an avenue for additional erosion to occur as a result of inlet formations and tidal rivulets. These modifications to the topography may result in hydrological changes that enable further sediment transport from the islands. This provides pathways for further erosion and saltwater intrusion into the less salt-tolerant interior vegetated habitats of the islands. This loss of elevation, combined with the shoreline retreat and removal of vegetation further aggravated by the hurricanes, allowed for the expansion of the overwash zone. This lessens the pre-storm protection provided by these barrier islands. The reduction in island elevation results in less frontline protection to valuable marshes and makes urban and industrial areas protected by these marshes at a higher risk (USDOC, NMFS, 2007a).

Hurricanes and tropical storms will remain a part of the Gulf Coast weather pattern and will continue to affect the elevations of barrier islands, mainland beaches, and dunes. Depending on storm frequency and intensity, it may be possible for coastal restoration and protection projects to mitigate some of the physical damage to these areas.

Navigation Channels, Vessel Traffic, and Pipeline Emplacements

The effects to coastal barrier beaches and associated dunes from pipeline emplacements, navigation channel use and dredging, and the construction or continued use of infrastructure in support of the CPA proposed action are expected to be restricted to temporary and localized disturbances. The estimated 0-1 pipeline landfall projected in support of the CPA proposed action is not expected to cause significant impacts to barrier beaches because of the use of nonintrusive installation methods. The estimated 0-1 gas processing plant would not be expected to be constructed on barrier beaches (Chapter 4.2.2.1.3.1 of the Multisale EIS). Existing inland facilities may, through natural erosion and shoreline recession, be located in the barrier beach and dune zone and contribute to erosion there. The proposed action may contribute to the continued use of such facilities. Maintenance dredging of barrier inlets and bar channels is expected to occur, which, when combined with channel jetties, generally cause minor and localized impacts on adjacent barrier beaches downdrift of the channel due to sediment deprivation. The greatest effects from this are on the sediment starved coasts of Louisiana, where sediments are largely organic. These impacts would occur whether the proposed action is implemented or not. The proposed action is not expected to adversely alter barrier beach configurations significantly beyond existing, ongoing impacts in localized areas downdrift of artificially jettied and maintained channels.

The CPA proposed action may extend the life and presence of facilities in eroding areas, which would accelerate localized erosion. The strategic placement of dredged material from channel maintenance, channel deepening, and related actions can mitigate adverse impacts upon those localized areas. With the established importance of barrier islands as frontline protection for both coastal wetlands and mainland

infrastructure, there are no current or future plans for routing navigation channels (if needed) through barrier islands.

A large temporary increase in vessel traffic in the CPA resulted from the DWH event. Large numbers of specialty fire fighting, dispersant, and skimmer vessels were concentrated around the Louisiana coast. Skimmers, tugboats, sand barges, and dredges comprised the bulk of the vessel traffic that was in near proximity to barrier islands as a result of berm construction. Due to the distance from the barrier islands and slow speed of these vessels, it is unlikely these vessels markedly increased erosion rates of these islands. As noted previously, the possibility of changes in current patterns as a result of sand mining and sediment placement, may affect natural island building. In the short term, these vessels and dredges have the potential to resuspend oiled bottom sediments that may exist in the area of these islands or mainland shorelines. However, it is doubtful that cumulative erosion that results from increased vessel traffic related to catastrophic spills would occur because the probability of catastrophic spills is small. Also, it is doubtful that there will be increases in production wells over the 40-year period of OCS exploration because older wells will come out of service as new wells come into service. This being the case, there should not be a sustainable cumulative increase in the need for supply and support vessels. This is because vessel traffic would either decrease or reach a state of equilibrium to meet the needs of the working wells. The entire current 5-Year Program accounts for only 12 percent of the commercial ship traffic. The CPA proposed action is now estimated to account for 2-3 percent (calculated from Table 4-4 of the Multisale EIS and **Table 3-2** of this Supplemental EIS) of the service-vessel traffic of the current 5-Year Program. Further details concerning vessel traffic can be found in Chapters 4.2.2.1.3.1 and 4.1.1.8.4 of the Multisale EIS. Navigation channels projected to be used in support of the CPA proposed action are discussed in Chapter 4.1.2.1.9 of the Multisale EIS.

Oil Spills

Sources and probabilities of oil entering waters of the Gulf and surrounding coastal regions are discussed in Chapter 4.1.3.4 of the Multisale EIS. Inland spills that do not occur in the vicinities of barrier tidal passes are more likely to contact the landward rather than the ocean side of a barrier island. Hence, no inland spills are expected to significantly contact barrier beaches (Chapter 4.2.2.1.3.1 of the Multisale EIS).

Most spills occurring in offshore coastal waters are assumed to proportionally weather and dissipate before hitting the Louisiana coast, as described in Table 4-36 of the Multisale EIS. Dispersants are not expected to be used in coastal waters. However, for offshore spills the dispersal of about 65 percent of the volume of a spill is attributed to the use of dispersants. No calculation has been made to estimate how much oil might be deposited on a beach if dispersants are not used. Unfavorable winds and currents would further diminish the volume of oil that might contact a beach. A persistent, northwesterly wind might preclude contact. As discussed in Chapter 4.5.3.1 of the Multisale EIS, the probability that tide levels could reach or exceed the elevations of sand dune vegetation on barrier beaches ranges from 0 to 16 percent. This depends on the particular coastal setting and the elevation of the vegetation. The strong winds (like those found with strong tropical storms) that would be needed to produce unusually high tide levels would also disperse the slick over a larger area than is considered in the current analysis. With the cumulative effect of successive hurricanes continually lowering the barrier and dune elevations and creating erosion pathways in mainland beaches, the probability of beach oiling increases. The probabilities of spill occurrence and contact with barrier beaches and sand-dune vegetation are considered low unless winds are sufficient to elevate tides over the now reduced barrier island elevations. Hence, contact of sand-dune vegetation by spilled oil is not expected to occur except in extreme storm conditions. Furthermore, the Mississippi River discharge would help dissipate a slick that might otherwise contact Plaquemines Parish, Louisiana. The mixing and spreading would reduce the oil concentrations contacting the beach and vegetation, greatly reducing impacts on vegetation.

Hurricanes and tropical storms will continue to erode and lower elevations of the barrier islands and to reduce their effectiveness as protection from inland oiling. While the probability of a catastrophic spill like the DWH event is low, it still has the potential to occur. As a result, some barrier islands could be oiled. Cleanup of these oiled islands and mainland beaches may involve utilizing heavy machinery that further impacts both beach and littoral habitats. Protective measures such as berm building (as discussed in the river channelization and beach protection section in this chapter) to prevent oiling may further

impact barrier islands through increasing compaction, altering currents, and removing sand supplies needed for natural barrier island formation. The barrier beaches of Deltaic Louisiana have the greatest rates of erosion and landward retreat of any known in the western hemisphere, and among the greatest rates on earth. Long-term impacts to contacted beaches from these spills could occur if significant volumes of sand were removed during cleanup operations. Removing sand from the coastal littoral environment, particularly in the sand-starved transgressive setting of coastal Louisiana, could result in accelerated coastal erosion. Spill cleanup is difficult in the inaccessible setting of coastal Louisiana. This analysis assumes that Louisiana would require the responsible party to clean the beach without removing significant volumes of sand or to replace the sand removed. Hence, cleanup operations are not expected to cause permanent effects on barrier beach stability. Within a few months, adjustments in beach configuration may result from the disturbance and movement of sand during cleanup. Mechanized cleanup was used in Alabama and Florida to remove tarballs from recreational beaches. While sand was not removed, but sifted in place to remove tarballs, scientists acknowledge that until long-term monitoring results have been analyzed, it is too soon to determine if there will be long-term effects on specific organisms that live in the interstitial sands of the beach face.

The results of an investigation on the effects of the disposal of oiled sand on dune vegetation in Texas showed no deleterious impacts on existing vegetation or colonization of the sand by new vegetation (Webb, 1988). Hence, projected oil contacts to small areas of lower elevation sand dunes are not expected to result in destabilization of the sand dune area or the barrier landform.

Some oil will penetrate to depths beneath the reach of the cleanup methods. The remaining oil would persist in beach sands, periodically being released when storms and high tides resuspend or flush through beach sediments. During hot, sunny days, tarballs buried near the surface of the beach sand may liquefy and cause a seep to the sand surface. The long-term stressors, including physical effects and the chemical toxicity of hydrocarbons, may lead to decreased primary production, plant dieback, and further erosion (Ko and Day, 2004b).

The cumulative effect of aging infrastructure has the potential for increasing spills from older pipelines, platforms, and refineries. Older pipelines either cannot or are not as easily monitored for potential problems or failures as the newer pipelines. The newer pipelines are manufactured to a more stringent safety standard and are constructed so that they may be easily inspected by instruments or manually. Spills are more likely to result from the older facilities especially during storm conditions because of the age of the pipeline or structure and the lack newer superstructure designed to withstand major storms.

As more improperly abandoned and marked shallow-water wells are removed from production, the potential for spills through vessel contact and leaks may increase. Without closer monitoring and inspection by the states responsible for regulating State waters, the cumulative effect of the old improperly abandoned wells could potentially result in frequent spills in larger numbers over time.

Recreational Use and Tourism

Most barrier beaches in the CPA are relatively inaccessible for regular recreational use because they are either located a substantial distance offshore as in Mississippi or are in coastal areas with limited road access as in Louisiana. Few beaches in the CPA have been, or are likely to be, substantially altered to accommodate recreational or industrial construction projects in the near future.

Most barrier beaches in Alabama and Florida are accessible to people for recreational use because of road access, and their use is encouraged. Recreational use of barrier beaches and dunes can have impacts on the stability of the landform. Vehicle and pedestrian traffic on sand dunes can stress and reduce the density of vegetation that binds the sediment and stabilizes the dune. Destabilized dunes are more easily eroded by winds waves and traffic. Recreational vehicles and even hikers have caused problems where road access is available and the beach is wide enough to support vehicle use as in Alabama, Florida, and a few places in Louisiana. Areas without road access have limited impacts by recreational vehicles. The CPA proposed action would not provide any additional access that would result in an additive cumulative impact to the barrier beaches and dunes.

There will continue to be seaside real-estate development where road access is available. The protection of dunes, beaches, and coastal environments will be regulated through the Coastal Zone Management (CZM) program. This assures that projects are constructed consistent with the Federal CZM

guidelines in order to preserve the integrity of the coastal ecosystem. Due to the continued occurrence of hurricanes, aging infrastructure, and proximity of some of the beaches to the oil production platforms, the possibility still exists of oil spills reaching recreational and barrier beaches. The potential for damage from oil cleanup can be minimized through utilizing nonintrusive removal techniques should the spill reach the shore.

Summary and Conclusion

River channelization, sediment deprivation, tropical and extra-tropical storm activity, sea-level rise, and rapid submergence have resulted in severe and rapid erosion of most of the barrier and shoreline landforms along the Louisiana coast. The barrier system of coastal Mississippi and Alabama are also supported on a coastal barrier platform of sand. Beach stabilization projects are considered by coastal geomorphologists and engineers to accelerate coastal erosion. Beneficial use of maintenance dredged materials and other restoration techniques could be required to mitigate some of these impacts.

The impacts of oil spills from both OCS and non-OCS sources to the sand-starved Louisiana coast should not result in long-term alteration of landforms, provided the beaches are cleaned using techniques that do not significantly remove sand from the beach or dunes. The barrier beaches of deltaic Louisiana, the Chenier Plain, and the region around Galveston have the greatest risks of sustaining impacts from oil-spill landfalls because of the high concentrations of oil production near those coasts. However, the majority of inshore spills are assumed to be small in scale (5 bbl; Table 4-13 of the Multisale EIS) and short in duration; therefore, impacts would be minor. Oil from most offshore spills is assumed to be weathered and dissipated by the time it would contact coastal beaches. The cleanup impacts of these spills could result in short-term (up to 2 years) adjustment in beach profiles and configurations as a result of sand removal and disturbance during the cleanup operations. Some contact to lower areas of sand dunes is expected. These contacts would not result in significant destabilization of the dunes. All cleanup efforts would be monitored to ensure the least amount of disturbance to the areas. The long-term stressors to barrier beach communities caused by the physical effects and chemical toxicity of an oil spill may lead to decreased primary production, plant dieback, and further erosion.

Under the cumulative scenario, new OCS-related and non-OCS pipeline landfalls are projected. These pipelines are expected to be installed using modern techniques, which cause little to no impacts to the barrier islands and beaches. Existing pipelines, in particular those that are parallel and landward of beaches, that were placed on barrier islands using older techniques and that left canals or shore protection structures have caused and will continue to cause barrier beaches to narrow and breach. Aging pipelines and infrastructure continue to be problematic, and the potential for spills could exist until they are replaced. Improperly abandoned wells can also have a potential to create spills, especially in the shallow State waters.

Recreational use of many barrier beaches in the western Gulf is intense due to their accessibility by road; however, because of the inaccessibility of most of the central Gulf barrier coast to humans, recreational use is not expected to result in significant impacts to most beaches. In conclusion, coastal barrier beaches have experienced severe adverse cumulative impacts from natural processes and human activities. Natural processes are generally considered the major contributor to these impacts, whereas human activities cause both severe local impacts and the acceleration of natural processes that deteriorate coastal barriers. Human activities that have caused the greatest adverse impacts are river channelization and damming, pipeline canals, navigation channel stabilization and maintenance, and beach stabilization structures. Deterioration of Gulf barrier beaches is expected to continue in the future. Federal, State (Louisiana), and parish governments have made efforts over the last 10 years to slow the landward retreat of Louisiana’s Gulf shorelines.

The CPA proposed action is not expected to adversely alter barrier beach configurations significantly beyond existing, ongoing impacts in localized areas downdrift of artificially jettied and maintained channels. The proposed action may extend the life and presence of facilities in eroding areas, which would accelerate erosion in those areas. Strategic placement of dredged material from channel maintenance, channel deepening, and related actions could mitigate adverse impacts upon those localized areas. The proposed action is not expected to increase the probabilities of oil spills beyond the current estimates. Thus, the incremental contribution of the CPA proposed action to the cumulative impacts on coastal barrier beaches and associated dunes is expected to be small.

4.1.1.4. Wetlands

The BOEMRE has reexamined the analysis for wetlands presented in the Multisale EIS and the 2009-2012 Supplemental EIS (addition of 181 South Area), based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for wetlands presented in the Multisale EIS or the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information and in consideration of the DWH event is presented in the following sections. A brief summary of potential impacts follows. Effects to coastal wetlands from the primary impact-producing activities associated with the CPA proposed action are expected to be low. The primary impact-producing activities associated with routine activities for the proposed action that could affect wetlands include pipeline emplacement, construction and maintenance, navigational channel use (vessel traffic) and maintenance, disposal of OCS-related wastes, and use and construction of support infrastructure in these coastal areas. Vessel traffic associated with the proposed action is expected to contribute minimally to the erosion and widening of navigation channels and canals. Deltaic Louisiana is expected to continue to experience the greatest loss of wetland habitat. Wetland loss is also expected to continue in coastal Texas, Mississippi, Alabama, and Florida, but at slower rates. The incremental contribution of the proposed action to the cumulative impacts on coastal wetlands is expected to be very small.

Routine activities in the CPA such as pipeline emplacement, navigational channel use, maintenance dredging, disposal of OCS wastes, and construction and maintenance of OCS support infrastructure in coastal areas are expected to result in low impacts. Indirect impacts from wake erosion and saltwater intrusion are expected to result in low impacts, which are indistinguishable from direct impacts from inshore activities. The potential impacts from accidental events, primarily oil spills, are anticipated to be minimal. The incremental contribution of the proposed action's impacts to the cumulative impacts to wetlands is small and expected to be negligible.

4.1.1.4.1. Description of the Affected Environment

A detailed description of various wetland types, processes, functions, and importance can be found in Chapter 3.2.1.2 of the Multisale EIS and in Chapter 4.1.3.2.1 of the Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The description of the wetlands resources that follows includes the historical types and location of the various wetland resources, the existing condition of these resources after several years of unprecedented hurricane activity, and possible effects from exposure of these resources to oil (based on current publicly available data) from the DWH event.

In general, coastal wetland habitats occur as bands around waterways. They are broad expanses of saline, brackish, and freshwater marshes; mud and sand flats; forested wetlands that consist of cypress-tupelo swamps; and mangrove and bottomland hardwood forests. Saline and brackish habitats support sharply delineated and segregated stands of single plant species. Fresh and low-salinity environments support more diverse and mixed communities of plants. High organic productivity and efficient nutrient recycling are characteristic of coastal wetlands. These wetland corridors also function as floodwater retention and purification areas as well as sites for local aquifer recharge. They provide habitats for a great number and wide diversity of resident plants, invertebrates, fishes, reptiles, birds, and mammals. Marsh environments are also important nursery grounds for many economically important fishes and shellfish juveniles. The marsh edge, where marsh and open water meet, is particularly important for its higher productivity and greater concentration of organisms. Emergent plants produce the bulk of the energy that supports salt-marsh dependent animals.

General Existing Condition of Louisiana Coastal Wetlands

According to the U.S. Department of the Interior, during the mid-1980's, 28 percent of Louisiana (3,557,520 ha; 8.790.823 ac) was considered wetlands (Dahl, 1990; Henfer et al., 1994). Wetland loss

rates in coastal Louisiana are well documented to have been as high as 10,878 ha/yr (42 mi^2/yr) during the late 1960's. Studies have shown that the landloss rate in coastal Louisiana for the period 1972-1990 slowed to an estimated 6,475 ha/yr (25 mi^2/yr) (Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1993). Over the next 50 years, Louisiana is projected to lose almost 17 mi^2/yr (4,403 ha) of coastline due to storms, sea-level rise, and land subsidence (Government Accountability Office, 2007). A recent evaluation of landloss rates suggests that landloss is not occurring as rapidly as previously estimated and that it has been relatively stable from the 1970's through 2004 (Barras et al., 2008). Barras et al. (2008) states that, during 1985-2004, the majority of the coastal landloss occurred on the Deltaic Plain at a rate of 3,885-4,144 ha/yr (15-16 mi^2/yr). For the same period, the Marginal Deltaic Plain showed a slight increase in land at a rate of 155 ha/yr (0.6 mi^2/yr) as a result of the growth of the Atchafalaya River and Wax Lake Delta Complexes. However, the Chenier Plain loss rate remained fairly stable at 518 ha/yr (2 mi^2/yr). The overall rate of coastal landloss between 1985 and 2004 was approximately 3,108 ha/yr (12 mi^2/yr). Annual rates of coastal landloss for 1985-2006 increased from 777 ha/yr (3 mi^2/yr) to 3,885 ha/yr (15 mi^2/yr), relative to the 1985-2004 trends. This 777 ha/yr (3 mi^2/yr) increase reflects the hurricane-induced acceleration of landloss. To demonstrate the effects of Hurricanes Katrina and Rita, the study also analyzed the loss rates between 2004 and 2006. During this period, open water (indicates landloss) increased coastwide by 51,282 ha (198 mi^2), the equivalent of 70 percent of the cumulative loss from 1978 to 2004. Hurricanes Katrina and Rita increased open water in coastal Louisiana by 56,720 ha (219 mi^2) between 2004 and 2005. However, between 2005 and 2006 recovery increased the land base by 5,439 ha (21 mi^2) in a short period of time. The land gain between 2005 and 2006 is equal to approximately 10 percent of the landloss (56,203 ha; 217 mi^2) estimated for 2004-2005 (Barras, 2006).

On April 20, 2010, the DWH event resulted in the largest oil spill in the history of the U.S. The oil continued to flow for 87 days before the well was capped. It is estimated that a total of about 4.9 million bbl were spilled into the GOM. This spill initially oiled shorelines along the Louisiana coast from extreme western Louisiana to portions of the Mississippi coast. Most of the Louisiana coast was exposed to some degree of oiling ranging from light to heavy, and the oil has degraded the quality of certain areas of wetland habitat. The information provided in this Supplemental EIS is from the best publicly available information that could be acquired outside of the NRDA process. With regards to the DWH event, the data from the SCAT observations, as compiled in the Unified Command Daily Report for October 12, 2010, indicated that, as of that date, 88.8 mi (142.9 km) of Louisiana were heavily oiled and 203.1 mi (326.9 km) of shoreline had light to traces of oil observed.

Chenier Plain

The Chenier Plain formed between Port Bolivar, Texas, and Atchafalaya Bay in Louisiana as a result of storms and tidal currents reworking and depositing the sediments of the Mississippi River and its delta over the past several thousand years. As a result, few tidal passes are found along this coast as compared with eastern Louisiana. This reduction in the tidal passes reduces movement of saline waters. As the area filled in, a series of shell and sand ridges formed parallel or oblique to the present-day Gulf Coast, and these ridges were later abandoned as sea level continued to fall. Mudflats formed between the ridges when localized hydrologic and sedimentation patterns favored deposition (summarized from USDOI, GS, 1998). This intermittent deposition isolated entrenched valleys from the Gulf, forming large lakes such as Sabine, Calcasieu, White, and Grand (Gosselink et al., 1979; Fisher et al., 1973). The eastern Chenier Plain that comprises the Calcasieu/Sabine Basin in Cameron and Calcasieu Parishes (southwest Louisiana) is approximately 630,000 ac (254,952 ha). This Basin contains about 312,500 ac (126,464 ha) of wetlands consisting of 32,800 ac (13, 274 ha) of fresh marsh, 112,000 ac (45,325 ha) of intermediate marsh, 158,200 ac (64,021 ha) of brackish marsh, and 9,500 ac (3,845 ha) of saline marsh (LaCoast.gov, 2010c). A total of 122,000 ac (49,373 ha) (28%) has been lost since 1932. Calcasieu and Sabine Lakes are the major waterbodies within the basin, and freshwater inflow to the basin occurs primarily through these lakes via the Calcasieu and Sabine Rivers. Marshes within the basin historically drained into these two large lakes. The Chenier Plain supports an extensive marshland interspersed with large inland lakes formed in river valleys that were drowned after the last glaciation (Mac et al., 1998). Brackish and intermediate salinity marshes are dominant in the estuarine areas of the Chenier Plain. They are tidal with wind-driven tides being more influential, and they occasionally inundate these areas. Since salinity in this

area ranges broadly, these habitats support a mix of marine and salt-tolerant freshwater plants with marsh-hay cordgrass (*Spartina patens)* generally dominant. These habitats are the most extensive and productive in coastal Louisiana.

Plant communities of freshwater marshes are among the most diverse of sensitive coastal environments. Annuals have a much greater presence in freshwater marshes than in estuarine areas. Dominance changes from season to season as a result of year-round, seed-germination schedules. Freshwater wetlands are extensive in the Chenier Plain due to the abundant rainfall and runoff, coupled with a ridge system that retains freshwater and restricts the inflow of saline waters. Tidal influences are minimal in these areas, although strong storms may inundate the area. This could either raise the salinity from seawater coming in or lower the salinity with increased precipitation. Depending on the species, this could case salinity and flooding stress. Detritus is not as readily exported and accumulates in the Plain, and it supports additional plant growth. Freshwater marsh plants are generally more buoyant than estuarine plants. In areas where detritus is thick, marsh plants may form floating marshes (flotants). Flotants occur in very low-energy environments. They are held together by surrounding shorelines and a weave of slowly deteriorating plant materials and living roots. Forested wetlands only occur in the flood plain regions of major streams, along the northern margin of the Chenier Plain. There, cypress-tupelo swamps grade through stands of black willow to bottomland hardwoods (LaCoast.gov, 2010c).

Subsidence and sea-level rise are natural processes that contribute to wetland deterioration, but under pristine conditions, marsh building and maintenance processes can maintain the coastal marshes through normal subsidence and sea-level rise. The combination of subsidence and sea-level rise in the Calcasieu/Sabine Basin is approximately 0.25 in/yr (6 mm/yr) (LaCoast.gov, 2010c). However, due to manmade alterations to the basin hydrology, the natural wetland-building process no longer occurs at its historic rate. These factors, in combination with tropical storms, continue to deteriorate the Chenier Plain. In the Sabine Basin the natural wetland-building processes no longer occur, but natural marsh maintenance processes can be fairly effective at keeping wetland loss rates low. As noted in the section above ("General Existing Conditions of Louisiana Coastal Wetlands"), the Chenier Plain loss rate remained fairly stable at 518 ha/yr (2 mi^2/yr) between 1985 and 2004, while other areas of coastal Louisiana deteriorated rapidly (Barras et al., 2008).

The Louisiana coast was impacted by a series of successive Category 3 and 5 hurricanes between 2005 and 2008. The Chenier Plain was subjected to extreme flooding and erosion along the coastal beaches and marshes. While it is too early to quantify the damages incurred to the existing resource, further discussion of the storms' effects are discussed in the "Hurricanes" section below. In addition to these natural effects, the coastline and the adjacent wetlands were exposed to oil from the DWH event, which occurred off the Louisiana coast in April 2010.

Mississippi River Delta Complex

The Mississippi River Delta Complex forms a plain that is composed of a series of overlapping riverine deltas that have extended onto the continental shelf over the past 6,000 years. Wetlands on this deltaic plain are the most extensive of those within the northern Gulf of Mexico. Sparse stands of black mangrove are found in the highest salinity areas of the Barataria and Terrebonne Basins. Extensive salt and brackish marshes are found throughout the southern half of the plain and east of the Mississippi River. Farther inland, extensive intermediate and freshwater marshes occur. East of the Mississippi River and south of Lake Pontchartrain, Louisiana, very few intermediate and freshwater wetlands occurred until the Caernarvon Freshwater Diversion was intermittently put into action in 1993. In freshwater areas, cypress-tupelo swamps are found flanking the natural levees and in areas that are impounded by dredged materials, levees, or roads. Bottomland hardwoods are on the numerous natural levees and in drained levee areas (USDOI, MMS, 2007b).

Except for leveed areas and the delta and basin of the Atchafalaya River, all of the Mississippi River deltas are generally experiencing succession towards wetter terrestrial and deeper water habitats. This is due to deltaic abandonment and human actions and their ensuing erosion. Most of these wetlands are built upon highly organic soils that are easily eroded, compacted, and oxidized. There are two active deltas in this area. The more active is in Atchafalaya Bay at the mouths of the Atchafalaya River and its distributary, Wax Lake Outlet. Because the Red River and approximately 30 percent of the Mississippi River have been diverted to the Atchafalaya River, large volumes of sediment are being delivered to the

shallow bay. As a result, extensive freshwater marshes, swamps, and bottomland hardwood forests are found in this river basin, and relatively few estuarine marshes.

The less active delta is at the mouth of the Mississippi River, which is referred to as the Belize or Birdfoot Delta. The Mississippi River has been channelized through most of this delta. This channelization greatly reduced the volume of sediments that the River contributes to its delta and the longshore currents near the mouths of its distributaries. A few manmade diversions have been installed and others are in the planning stage. Diversions are designed to deliver water rather than sediments to this delta. However, through the Louisiana Coastal Wetlands Planning, Protection and Restoration Act Program (LaCoast.gov, 2010a), projects are being either planned or designed to provide not only additional freshwater diversions but also sediment delivery projects that are intended to assist in creating and restoring marshes in the Mississippi Deltaic Plain (LaCoast.gov, 2010b). Some of these projects include manmade crevasses in the Mississippi River levee. Examples are the Delta Wide Crevasse project, which is intended to create marsh; Mississippi Channel Armor Gap and West Bay projects. which are designed as sediment and water diversions; and Barneys Bay Diversion, which is intended to provide water and sediment to the disappearing marsh zones (LaCoast.gov, 2010b). The State of Louisiana is also utilizing dustpan dredges in these areas for deposition of sediment to these sediment-starved areas of the coast. Smaller shoreline regressions also occur as a result of jetties located on the eastern end of Grand Isle, the western end of Caminada-Moreau Beach, the Empire Navigational Canal, and elsewhere.

Most dune zones of the Mississippi River Delta contain low, single-line dune ridges that may be sparsely to heavily vegetated. Generally, in this area the vegetation on dune ridges gets denser as the time between storms increases. The shorefaces of the Mississippi River Delta Complex generally slope very gently seaward, which reduces wave energies at the shorelines. Mud flats are exposed during very low tidal events. The slope here is not as shallow as that found off the Chenier Plain. The steepest shoreface of the delta is found at the Caminada-Moreau Coast, where the greatest rates of erosion are seen. At this site, the longshore currents split to the east and west, which removes sand from the area without replenishment (Wolfe et al., 1988; Wetherell, 1992; Holder and Lugo-Fernandez, 1993).

Unfortunately, the past decade has seen an increase in tropical storm activity for the project area. Hurricane Katrina (August 2005) caused severe erosion and landloss for the coastal barrier islands of the Deltaic Plain. Currently, the intense hurricane activity in the Gulf over the past 6 years has accelerated either wetland loss or changes in composition or pattern of wetland vegetation in the area. This has occurred with the help of both manmade and storm-induced changes in hydrology (Steyer et al., 2008), which have resulted in salinity changes and the removal of protected headlands or beaches. Further discussion of changes in the delta hydrology and damages to wetlands from Hurricanes Katrina, Rita, Ike, and Gustav are discussed under the “Hurricanes” section below.

Aside from the effects of these tropical storms, the Mississippi River Delta Complex and the majority of the Louisiana coast was exposed to some degree of oiling. More information on areas of shoreline exposed to oil from the DWH event is included below in this chapter. These shoreline numbers reflect conditions as of the Unified Command Report date of October 12, 2010 (U.S. Dept. of Homeland Security, CG, 2010d), and are not necessarily indicative of past conditions of oiling. Some areas may have been either lightly or heavily oiled in the past, but these details will not be known until after the NRDA is completed and data are publicly available. The marshes and shorelines in the Birdfoot Delta portion of the Mississippi Delta Complex had the earliest and most severe exposure to shoreline oiling. Based on publicly available data from the FWS’s SCAT on September 27, 2010, (USDOI, FWS, 2010a), approximately 98 mi (158 km) of shoreline were noted as moderate to heavily oiled and included areas within and around the Mississippi Delta, Barataria Bay, Terrebonne Bay, and Bay Jimmy. At this point in time, it can only be said that these coastlines and the adjacent barrier islands have had some degree of exposure to oil. This oil has either been treated and/or weathered but we do not have available data to indicate the toxicity, quantity, or spatial extent of the shoreward exposure. This information should be forthcoming and made public as the NRDA Team completes the assessment process.

Mississippi and Alabama

According to DOI, during the mid-1980’s, 14 percent of Mississippi and 8 percent of Alabama were considered wetlands (Dahl, 1990; Henfer et al., 1994). Historically, vegetated coastal wetlands along the Mississippi coast included salt and brackish marshes, tidal freshwater marshes and swamps, and

submerged aquatic vegetation beds. Between 1930 and 1973, approximately 8,170 ac (3,308 ha) of coastal marshes were filled for industrial and residential uses. It was estimated in 1973 that Mississippi contained over 66,108 ac (26,764 ha) of salt marshes and approximately 823 ac (33 ha) of freshwater marshes (Mississippi Dept. of Marine Resources, 1999). Today, Mississippi has approximately a total of 72,000 ac (113 mi^2) of designated crucial coastal wetland habitat (Mississippi Dept. of Marine Resources, 2006). Estuarine wetlands are the second most common wetlands in Mississippi and include coastal, estuarine, and fresh marshes; mud flats; and cypress-tupelo gum swamp (estuarine forested wetlands). The estuarine marshes around Mississippi Sound and associated bays occur in discontinuous bands. The most extensive wetland areas in Mississippi occur in the eastern Pearl River delta near the Louisiana/Mississippi border and in the Pascagoula River delta area near the Mississippi/Alabama border. Mississippi's wetlands seem to be more stable than those in Louisiana and Alabama, perhaps reflecting the more stable substrate, active and less disrupted sedimentation patterns, and occurrence of only minor canal dredging and development. Urban and suburban growths are suggested as the greatest contributors to direct coastal wetland loss in Mississippi and Alabama.

The Gulf Coast of Alabama extends the length of the state, a distance of only 74 km (46 mi) (Alabama Coastal Area Board, 1980). The coastline includes the estuaries and inlets that cover a greater distance of 977 km (607 mi) (USDOC, NOAA, 1997). Two large drainage basins empty into the northern Gulf of Mexico within coastal Alabama; they are the Perdido River Basin and the Mobile River Basin. The Perdido Basin encompasses 3,238 km^2 (1,250 mi^2) of Alabama and Florida (Sturm et al., 2007). The Mobile Basin is the sixth largest drainage area and the fourth largest river basin in terms of flow volume in the United States. The 111,370-km^2 (43,000-mi^2) Mobile Basin encompasses parts of Tennessee, Georgia, Mississippi, and Alabama (Isphording and Flowers, 1990; Johnson et al., 2002).

The coastal lowlands of Alabama, with gently undulating to flat topography, basically follow the shoreline along the Gulf of Mexico and Mobile, Perdido, and Bon Secour Bays (Sapp and Emplaincourt, 1975). The ecological environments and geomorphology consist of features such as wetlands (e.g., tidal marsh), two large peninsulas, a delta, lagoons, islands, and bays. The presence of a high water table with a range of salinities gives rise to the abundance of various wetland habitat types that are found within Alabama's coastal area. The largest bays of coastal Alabama stated in size order include Mobile Bay, Perdido Bay, and Bon Secour Bay. The largest of these is Mobile Bay and it was formed within a submerged river valley (Chermock, 1974). Some of Perdido Bay is in Florida and contains areas populated by seagrasses. The Mississippi Sound estuary, located behind the offshore barrier islands, extends from southwestern Mobile Bay and borders the entire southern Mobile County and Mississippi coastlines. The Mobile, Tensaw, and Blakeley Rivers flow southward to Mobile Bay through the Mobile-Tensaw Delta. The alluvial-deltaic plain is located at the terminus of Mobile Bay to northward along the Mobile-Baldwin County line. Topographically, the Mobile-Tensaw Delta is flat and generally below 6 m (20 ft) in elevation. Additionally, other major coastal tributaries include Dog and East Fowl Rivers on the western side of Mobile Bay and the Blakeley, Fish, Magnolia, and Bon Secour Rivers on the eastern side of the Bay. West Fowl and Escatawpa Rivers discharge into Mississippi Sound, and the Perdido and Blackwater Rivers are located at the northern end of Perdido Bay. Alabama has approximately 118,000 ac (184 mi^2) of coastal wetlands, of which approximately 75,000 ac (117 mi^2) are forested; 4,400 ac (9 mi^2) are freshwater marsh; and 35,400 ac (55 mi^2) are estuarine marsh (Wallace, 1996). Most coastal wetlands in Alabama occur on the Mobile River Delta or along the northern Mississippi Sound.

Both Mississippi and Alabama have estuarine intertidal emergent habitats that include salt marsh, as well as intertidal forested shrub that can include mangroves and other salt tolerant shrubs. The embayments and shallow-water environments in these coastal waters also have estuarine aquatic beds that may include submergent or floating vegetation (Swann, 2010). Mississippi had a loss with the original 10 million acres of marshes in the 1780's dwindling to approximately 4 million acres by the 1900's representing a 59 percent loss (Dahl, 1990). Coastal Mississippi is predominantly salt marsh habitat with very little fresh marsh. The observed loss rates is coastal Mississippi reflect this discrepancy in habitat with losses of 64,000 acres of salt marsh and only 800 acres of fresh marsh (Swann, 2010). In Alabama approximately 15,000 acres of salt marsh was lost as opposed to 11,000 acres of fresh marsh. Based on historical records Alabama had approximately 7.6 million acres of marsh in the 1780's and by the 1980's was left with 3.6 million acres representing a 50 percent loss in marsh acreage. The existing conditions associated with channel maintenance (dredging and filling), bank armoring, vessel wakes, propeller wash, coastal development, subsidence, and sea level rise will continue as part of sources aggravating the loss of

coastal marshes. Federal and State coastal initiatives (e.g., CIAP and CWPPRA) are either ongoing or being expanded to restore, protect, or construct wetlands and further prevent coastal wetland loss. Overall coastal wetlands in these areas have been greatly reduced approximately 50 percent of historical values. The sparse data available since the 1980's suggest that losses have slowed (Swann, 2010). Another important factor in wetland loss over the past 6 years has been the extremely active hurricane season. These natural forces, along with the currently unknown long-term effects of the DWH event, may further affect the sustainability of these coastal marshes. There were 9 and 81 mi (14 and 130 km), respectively, of shoreline in Mississippi exposed to either heavy or light shoreline oilings. The SCAT observations are not indicating any moderate to heavy oil exposure along the Alabama shoreline, but some light oiling was noted along 60 mi (97 km) of shoreline. Florida had no heavily oiled shoreline as of the October report date, but 114 mi (183 km) of light to traces of oil were found along the Alabama shoreline. At this point in time it can only be said that these coastlines and the adjacent barrier islands have had some degree of exposure to oil, which has either been treated or weathered; however, we do not have available data to indicate toxicity, quantity, or spatial extent of the shoreward exposure. This information should be forthcoming and made public as the NRDA Team completes the assessment process.

Hurricanes

The intensity and frequency of hurricanes in the Gulf over the last 6 years has greatly impacted the system of protective barrier islands, beaches, and dunes and associated wetlands along the Gulf Coast. Within the last 6 years, the Gulf Coast of Texas, Louisiana, Mississippi, Alabama, and to some degree Florida have experienced five major hurricanes (Ivan, Katrina, Rita, Gustav, and Ike). As a result of losing dune and barrier island elevations, as well as associated marshes and backshore and foreshore wetlands, the inland coasts and wetlands are more vulnerable to future hurricanes and wind-driven tidal or storm events.

The post-storm (Hurricanes Katrina and Rita) estimates of land change made by USGS (Barras, 2006) indicated that there was an increase of 217 mi^2 (562 km^2) of open water following the storm. Based on the analysis of the latest satellite imagery (Barras, 2007b), approximately 82 mi^2 (212 km^2) of new open-water locations were in areas primarily impacted by Hurricane Katrina (e.g., Mississippi River Delta Basin, Breton Sound Basin, Pontchartrain Basin, and Pearl River Basin), whereas 99 mi^2 (256 km^2) were in areas primarily impacted by Hurricane Rita (e.g., Calcasieu/Sabine Basin, Mermentau Basin, Teche/Vermilion Basin, Atchafalaya Basin, and Terrebonne Basin). The Barataria Basin contained open-water locations caused by both Hurricanes Katrina and Rita, resulting in some 18 mi^2 (46.6 km^2) of open water. The fresh and intermediate marsh land decreased by 122 mi^2 (316 km^2) and 90 mi^2 (233.1 km^2), respectively. The brackish and saline marsh land decreased by 33 mi^2 (85.5 km^2) and 28 mi^2 (72.5 km^2), respectively. Based on current observational flights by USGS, wetland recovery 6 years after Hurricane Katrina is noted as slow (Israel, 2010,), with open water remaining where viable marshes once existed. The marshlands east of the Mississippi Delta were the most severely affected. According to the USGS's 5-year, post-Katrina survey, the wetland loss from all four storms (i.e., Hurricanes Katrina, Rita, Gustav, and Ike) totaled 340 mi^2 (881 km^2). Hurricanes Katrina and Rita alone destroyed 220 mi^2 (570 km^2) (Israel, 2010).

Intense storms typically blow away all of the vegetation and soil from marsh, leaving behind a body of water. Hurricane Katrina was no exception, leaving scour holes where debris accelerated by the storm pushed the marsh away. Based on the depths of these scours, marsh type (i.e., fresh, intermediate, brackish, or saline), sediment supply, and drainage, possible recovery time is determined. However, it is too early to determine if long-term recovery is viable. Another factor that is now superimposed on the hurricane damage is the currently unknown, long-term effect of the oil spill from the DWH event. All of these factors must now be considered as part of the existing environment.

4.1.1.4.2. Impacts of Routine Events

Background/Introduction

A detailed description of routine impacts from the CPA proposed action to wetlands is given in Chapter 4.2.1.1.3.2 of the Multisale EIS and in Chapter 4.1.3.2.2 of the 2009-2012 Supplemental EIS.

The following is a summary of the information presented in the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

This section considers impacts from routine activities associated with the CPA proposed action to coastal wetlands and marshes. The primary impact-producing activities associated with the proposed action that could affect wetlands and marshes include pipeline emplacement, construction, and maintenance; navigation channel use (vessel traffic) and maintenance dredging; disposal of OCS-related wastes; and use and construction of support infrastructure in these coastal areas. Other potential impacts that are indirectly associated with OCS oil and gas activities are wake erosion resulting from navigational traffic, levee construction that prevents necessary sedimentary processes, saltwater intrusion that changes the hydrology leading to unfavorable conditions for wetland vegetation, and vulnerability to storm damage from eroded wetlands. The following sections describe the sources and types of these potential impacts. In addition to the above effects, the DWH event oil spill presents other potential indirect effects as a result of disturbing remnant oil in the sediment. It is highly unlikely that the remnant oil is toxic due to weathering time, biological degradation, and dispersant treatment. Routine activities involving bottom disturbances (dredging, waste disposal, and trenching associated with pipeline placement) or sediment or water entrainment (shallow-water vessel traffic) could potentially resuspend or transport this bottom based oil.

It was estimated in 2000 that coastal Louisiana would continue to lose land at a rate of approximately 26 km^2/(10 mi^2/) over the next 50 years. Further, it was estimated that an additional net loss of 1,326 km^2 (512 mi^2) may occur by 2050, which is almost 10 percent of Louisiana's remaining coastal wetlands (Barras et al., 2003). However, in 2005 Hurricanes Katrina and Rita caused 562 km^2 (217 mi^2) of land change (primarily wetlands to open water) (Barras, 2006). Based on the analysis of the latest satellite imagery, approximately 212 km^2 (82 mi^2) of additional open-water habitat was in areas primarily impacted by Hurricane Katrina (e.g., Mississippi River Delta Basin, Breton Sound Basin, Pontchartrain Basin, and Pearl River Basin) (Barras, 2007b and 2009). Also, 256 km^2 (99 mi^2) of open-water habitat was in areas primarily impacted by Hurricane Rita (e.g., Calcasieu/Sabine Basin, Mermentau Basin, Teche/Vermilion Basin, Atchafalaya Basin, and Terrebonne Basin). Barataria Basin contained approximately 46.6 km^2 (18 mi^2) of new open-water habitat caused by both hurricanes. These new open-water habitats represent landloss caused by the direct removal of wetlands. They may also indicate transitory changes of wetlands to open water caused by remnant flooding, removal of aquatic vegetation, scouring of marsh vegetation, and water-level variation attributed to normal tidal and meteorological variation between satellite images. An accurate evaluation of permanent loss of wetland areas is difficult until several growing seasons have been evaluated. The presence of strong tropical storms is a routine background condition in the Gulf that must be taken into consideration. Coastal change from storms in the area included both beach erosion and erosion of channels where water continues to flow seaward to the Gulf of Mexico (Doran et al., 2009). These eroded barriers that once protected the wetlands behind them were severely eroded by the storms. The cumulative effects of human and natural activities in the coastal area have severely degraded the deltaic processes and have shifted the coastal area from a condition of net land building to one of net landloss and are discussed in **Chapter 4.1.1.4.4** (U.S. Dept. of the Army, COE, 2004a).

Pipeline Emplacement

As of July 2006, there was over 45,000 km (27,962 mi) of pipelines in Federal offshore lands. Approximately 15,400 km (9,569 mi) of OCS pipelines extend into State waters and onshore. For the CPA proposed action, there would be 130-2,075 km (81-1,289 mi) of installed pipelines (**Table 3-2**). Many OCS pipelines make landfall on Louisiana's barrier island and wetland shorelines. Approximately 8,000 km (4,971 mi) of OCS-related pipelines cross marsh and uplands (Johnston et al., 2009). Louisiana wetlands protect pipelines from waves and ensure that the lines stay buried and in place (**Chapter 3.1.2.3**). Existing pipelines, especially those installed prior to the State of Louisiana Coastal Permit Program in 1981, have caused direct landloss averaging between 2.5 ha/(10 ac/) and 4.0 ha/(16 ac/) of linear pipeline (Bauman and Turner, 1990; Johnston et al., 2009). Bauman and Turner (1990) indicated that the widening of OCS pipeline canals does not appear to be an important factor for total net wetland loss in the coastal zone because few pipeline canals are open to navigation.

Since 2002, only one new pipeline has come to shore in Louisiana from OCS-related activities. In 2003, the 30-in Endymion Oil Pipeline, which delivers crude oil from South Pass Block 89 to the LOOP storage facility near the Clovelly Oil and Gas Field, was installed. Based on a review of the data in the COE permit application (No. 20-020-1632), the emplacement of the pipeline caused zero (0) impacts to marshes (emergent wetlands) and beaches. This is because the operator used horizontal, directional (trenchless) drilling techniques to avoid damages to these sensitive habitats. Additionally, the pipeline route maximized an open-water route to the extent possible (a comprehensive description of current mitigation measures is discussed in **Chapter 2.2.2**). A comparison of aerial photos taken before and after Hurricanes Katrina and Rita reveal no observable landloss or impacts associated with the Endymion Oil Pipeline. Impacts to wetlands from routine activities associated with the proposed action are expected to be low and could be further reduced through mitigation. However, in areas where oiling of wetlands occurred from the DWH event, there is the potential for disturbing oiled sediment and vegetation. It is possible that any dredging or trenching associated with pipeline placement could result in the disturbance of oiled sediment and could potentially result in the spread of any associated contaminants to wetlands. Maintenance dredging of navigation channels and canals is expected to occur with minimal impacts except in areas that have been previously contaminated with oil; however, the proposed action is expected to contribute minimally to the need for this dredging. Alternative dredged material disposal methods can be used to enhance and create coastal wetlands after material has been tested for the presence of oil toxicity. Vessel traffic associated with the proposed action is expected to contribute minimally to the erosion and widening of navigation channels and canals. Secondary impacts to wetlands would be primarily from vessel traffic corridors and will continue to cause approximately 0.6 ha (1.5 ac) of landloss per year, regardless of the CPA proposed action.

Dredging

The COE's New Orleans District annually removes approximately 69 million m^3 (90 million yd^3) of dredged material from 10 Federal navigational channels throughout coastal Louisiana. Approximately 18 million m^3 (27 million yd^3) or 25-35 percent of this material is used for coastal wetland restoration projects (Creef and Mathies, 2002). As a result of the tremendous wetlands landloss in the Louisiana coastal region, the beneficial use of dredge spoils is expected to increase. Executive Order 11990 (1977) requires that, where appropriate, material from maintenance dredging be considered for use as a sediment supplement in deteriorating wetland areas to enhance and increase wetland acreage. Given the COE's policy of beneficial use of dredge, increased emphasis has been placed on the use of dredged material for marsh creation. For the proposed action, increased use of dredged material to enhance wetland habitats is encouraged as mitigation.

Dredging and dredged-material disposal can be detrimental to coastal wetlands and associated fish and wildlife that use these areas for nursery grounds, protection, etc. As a result of the DWH event, dredging may result in the resuspension and transport of oiled sediments in areas where oil is known to have once occurred. Maintenance dredging of navigation channels deposits material on existing disposal banks and areas. The effects of these disposal banks from the proposed action in the CPA on wetland drainage is expected to continue unchanged, except if there are some localized and minor exacerbation of existing problems. For example, some dredged material intended for placement on a dredged-material disposal bank is placed in adjacent wetlands or shallow water. Wetland loss due to dredge material deposition is expected to be offset by wetland creation as adjacent margins of shallow water are filled. In both cases, areas impacted are considered small. Maintenance dredging would also temporarily increase turbidity levels in the vicinities of the dredging and disposal of materials, which can impact emergent wetlands and submerged vegetation communities.

Two different methods are generally used to dredge and transport sediments from channels to open-water sites: (1) a hydraulic cutterhead suction dredge transfers sediments via connecting pipelines or (2) a clamshell bucket dredge transfers sediments via towed bottom-release scows. Each method produces a distinctly different deposit. Hydraulic dredging creates a slurry of sediment and water, which is pumped through a pipeline to the dredged-material disposal site. Coarser sediment settles to the bottom where it spreads outward under the force of gravity, and finer sediments may remain in suspension longer. The clamshell dredge scoops sediments relatively intact into scows, which are then towed to the designated

area. The dredged sediments are released into the area specified for disposal. This method usually produces positive relief features in the placement area.

Access canals, as well as pipeline canals, are commonly bordered by levees created using dredged materials (Rozas, 1992). Placement of this material alongside canals converts low-lying marsh to upland, an environment unavailable to aquatic organisms except during extreme high tides. Dredged material can also form a barrier, causing ponding behind levees and limiting circulation between canal waters and marshes to infrequent, high-water events (Swenson and Turner, 1987; Cox et al., 1997). This and similar disruptions to marsh hydrology are believed to change coastal habitat structure as well as accelerate marsh erosion and conversion to open water (Turner and Cahoon, 1988; Rozas, 1992; Turner et al., 1994; Kuhn et al., 1999).

Navigation Channels and Vessel Traffic

Vessel traffic that may support the proposed action is discussed in Chapter 4.1.1.8.4 of the Multisale EIS, in Chapter 3.1.1.4 of the 2009-2012 Supplemental EIS, and in **Chapter 3.1.2** of this Supplemental EIS. Most navigation channels projected to be used to support the CPA proposed action are shallow and are currently used by vessels that support the OCS Program (Chapter 4.1.2.1.9 and Table 3-36 of the Multisale EIS). Approximately 3,200 km (1,988 mi) of OCS-related navigation canals, bayous, and rivers are found in the coastal regions around the Gulf. This is exclusive of channels through large bays, sounds, and lagoons. About 2,000 km (1,243 mi) support OCS-related activities in the CPA. No new navigation channels are expected as a result of the CPA proposed action. Deepwater activities are anticipated to increase, requiring use of larger service vessels for efficient operations. This may put a substantial emphasis on shore bases associated with deeper channels. Ports that have navigation channels deep enough to accommodate deeper-draft vessels may expand their infrastructure to accommodate deeper-draft vessels. An example of a significant expansion of a service base is Port Fourchon in coastal Louisiana. Port Fourchon has deepened the existing channel and has dredged additional new channels to facilitate this expansion. At present, the entrance to Port Fourchon (Belle Pass Channel) is maintained at 9 m (29 ft). The inland channel in the port is 8 m (26 ft) and Bayou Lafourche is maintained at 7 m (24 ft). The Federal Emergency Management Agency (FEMA) has funded the dredging of several sites that were silted by Hurricanes Katrina and Rita.

Waves generated by boats, ships, barges, and other vessels erode unprotected shorelines and accelerate erosion in areas already affected by natural erosion processes. Much of the service-vessel traffic that is a necessary component of OCS activities uses the channels and canals along the Louisiana coast. According to Johnson and Gosselink (1982), canal widening rates in coastal Louisiana range from about 2.58 m/(8.46 ft/) for canals with the greatest boat activity to 0.95 m/(3.12 ft/) for canals with minimal boat activity. This study found navigational use is responsible for an average of 1.5 m/yr (4.9 ft/yr) of the canal widening. About 2,000 km (1,243 mi) of navigation channels support OCS-related activities in the CPA. Total navigational use results in about 300 ha (741 ac) of landloss per year. A USGS study by Johnston et al. (2009) found that canal widening rates have slowed rather than increased in recent years as a result of increased bank stabilization efforts. Thus, the canal widening rates established by Johnson and Gosselink (1982) are considered overestimates. The most heavily-used OCS navigation channel is the channel from Port Fourchon which is heavily armored and is less erodible. A recent BOEMRE- and USGS-funded study (Thatcher et al., 2011) is examining the susceptibility to erosion of navigation channels based on cover and substrate. During the study, the shorelines along both banks of navigation canals were mapped using aerial photography from 1978 to 1979, 1996 to 1997, and 2005 to 2006. To measure shoreline changes, transects were generated. The erosion rates were quantified to determine whether differences in erosion rates are related to embankment substrate, vegetation type, geologic region, or soil type. The study found erosion rates were variable within and across unarmored portions of the navigation channels. Previous studies have found that canal erosion rates have slowed in recent years, and the results of this study support that conclusion. The rate of change differed significantly by geologic region and marsh vegetation type. However, when rates for all canals were combined for each time period, the average canal widening rate slowed to -0.99 m/yr (-3.25 ft/yr) for the 1996/1998-2005/2006 time period compared with -1.71 m/yr (-5.61 ft/yr) for the earlier 1978/1979-1996/1998 time period. Therefore, this indicates there is a decrease in the rate of erosion for the area during that time period.

Disposal of OCS-Related Wastes

Produced sands, oil-based or synthetic-based drilling muds and cuttings, along with fluids from well treatment work over and completion activities would be transported to shore for disposal. Sufficient disposal capacity exists at the disposal site near Lacassine, Louisiana, and at other disposal sites under development or projected for future development. Discharging OCS-related produced water into inshore waters has been discontinued, so all OCS-produced waters are discharged into offshore waters in accordance with NPDES permits or transported to shore for injection. Produced waters are not expected to affect coastal wetlands. Because of wetland protection regulations, no new waste disposal site would be developed in wetlands. Some seepage from waste sites into adjacent wetland areas may occur and may result in damage to wetland vegetation. State requirements are expected to be enforced to prevent and correct such occurrences.

Onshore Facilities

Various kinds of onshore facilities service OCS development. All projected new facilities that are attributed to the OCS Program and the CPA proposed action are described in **Chapter 3.1.2**. State and Federal permitting agencies discourage the placement of new facilities and the expansion of existing facilities in wetlands. Any impacts upon wetlands are mitigated.

Overview of Existing Mitigation Techniques and Results

Numerous mitigation methods have been recommended and used in the field. Depending on the location, project, and surrounding environment, different mitigation techniques may be more appropriate over another. Based on permits, work documents, and interviews, 17 mitigation techniques have been implemented at least once with regards to the OCS. Because no one technique or suite of techniques are routinely required by permitting agencies, each pipeline mitigation process is uniquely designed to minimize damages given the particular setting and equipment to be installed. Of the identified mitigation techniques, there are a number of techniques that are commonly required. Some other mitigation techniques are rarely used because they are considered obsolete or because they are applicable only to a narrow range of settings. Table 4-42 of the Multisale EIS summarizes the recommended mitigating techniques to reduce or avoid adverse impact to wetlands from pipeline construction, canals, dredging, and dredged material placement. These mitigation methods are the most common applied by the permitting agencies (COE and the State in which the activity has or would occur) to minimize wetland impacts. The BOEMRE is not a permitting agency for onshore pipelines, canals, dredging, and dredged material placement.

Proposed Action Analysis

Zero to one pipeline landfalls that could result in up to 2 km (1.2 mi) onshore pipeline are projected as a result of the CPA proposed action. Should one be constructed, it would most likely be in Louisiana, where the large majority of infrastructure exists for receiving oil and gas from the CPA. Pipeline landfall may occur through or in the immediate vicinity of coastal wetlands and marshes. Wherever a landfall occurs, permitting/mitigating processes are in place to ensure wetland habitats are protected first through avoidance, then minimization of impacts, and finally compensation for unavoidable impacts to wetlands. The use of modern technologies, such as directional boring, greatly reduces and possibly eliminates impacts to coastal wetlands and marshes. About 5-8 ha (12-20 ac) of landloss for the projected 2 km (1.2 mi) of pipeline (based on historic loss rates) are expected from the CPA proposed action. This represents approximately 0.25 percent of the total landloss estimated to occur along the Louisiana coast in 1 year (~2,590 ha or 10 mi^2) (Barras et al., 2003). This estimate does not take into account the present regulatory programs of COE and the Louisiana Dept. of Natural Resources, modern installation techniques, and “no net loss” policy that would result in zero to negligible impacts to wetland habitats. Therefore, effects on coastal wetlands and marshes from new pipeline laying activities associated with the CPA proposed action are expected to be minor or nonexistent. These impacts are considered to be negligible. For the proposed action, increased use of dredged material to enhance wetland habitats is encouraged as mitigation.

On average, 12 percent of traffic using OCS-related navigation channels is related to the OCS Program (Tables 3-36 and 4-4 of the Multisale EIS). Based on the numbers of service-vessel trips projected for the proposed action and the OCS Program (**Table 3-2**; and Table 4-6 of the Multisale EIS), the proposed action is expected to contribute 3-4 percent of the total OCS Program usage. So, the proposed action would contribute 0.4-0.5 percent to the total commercial traffic using these navigation channels. All estimated navigational use is expected to contribute approximately 1.5 m/(4.9 ft/) to the widening to the roughly 2,000 km (1,243 mi) of OCS-related navigation channels, or about 300 ha (741 ac), of landloss per year. Twelve percent or 36 ha (89 ac) can be attributed to wake erosion from OCS-related vessel traffic (note that several other factors including storms, tides, and subsidence also contribute to canal widening). Of the 3,600 ha (8,896 ac) attributed to total OCS-related wake erosion, about 1 ha (3 ac) of landloss per year would be attributed to the CPA proposed action. Therefore, impacts from vessel traffic related to the proposed action should remain minimal. Because of wetland protection regulations, no new waste disposal site would be developed in wetlands. Some seepage from waste sites into adjacent wetland areas may occur and result in damage to wetland vegetation. State requirements are expected to prevent and correct such occurrences. No effects to coastal wetlands from the disposal of OCS-related wastes associated with the CPA proposed action are expected.

Summary and Conclusion

The 0-2 km (0-1.2 mi) of onshore pipeline that could result from the proposed action would cause the loss of 0-8 ha (0-20 ac) of wetlands habitat. It is expected that these impacts would be reduced through mitigation, such as horizontal, directional (trenchless) drilling techniques to avoid damages to these sensitive wetland habitats. Although maintenance dredging of navigation channels and canals in the CPA is expected to occur, the proposed action is expected to contribute minimally to the need for this dredging. Alternative dredged-material disposal methods can be used to enhance and create wetlands. Secondary impacts to wetlands from the CPA proposed action would result from OCS-related vessel traffic contributing to the erosion and widening of navigation channels and canals. This would cause approximately 1 ha (3 ac) of landloss per year. Overall, the impacts to wetlands from routine activities associated with the CPA proposed action are expected to be low due to the small length of projected onshore pipelines, the minimal contribution to the need for maintenance dredging, and the mitigation measures that would be used to further reduce these impacts.

4.1.1.4.3. Impacts of Accidental Events

Background/Introduction

A detailed description of the wetlands resource and accidental impacts from the CPA proposed action are given in Chapters 3.2.1.2 and 4.4.3.2 of the Multisale EIS and in Chapters 4.1.3.1.1 and 4.1.3.2.3 of the 2009-2012 Supplemental EIS. There is also a risk analysis of accidental events in **Chapter 3.2.1** of this Supplemental EIS. The following is a summary of the information presented in the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared. The main impact-producing factors that would affect wetlands are oil spills.

Since the preparation of the Multisale EIS and the 2009-2012 Supplemental EIS, the coastal wetlands, along with their protective barrier islands, have been heavily impacted by two intense hurricanes in 2008 (Gustav and Ike). These already eroding, protective barrier islands were further reduced in mass and elevation. As a result, there have been losses in the protective landmass (Chandeleur Island) and elevations of the barrier islands, as well as the conversion of wetlands to open water through erosion, scour, and saltwater intrusion as noted in Barras et al. (2008). With the reduced protection of the barrier islands, there is a greater potential for the oiling of coastal wetlands. Both coastal and offshore oil spills can be caused by large tropical cyclone events such as Hurricanes Katrina, Rita, Gustav, and Ike.

In addition to hurricane effects, areas of the Louisiana coast have been further stressed through shoreline oiling associated with the DWH event. While most of the Louisiana coastline received some degree of oiling, the most heavily oiled areas were around the Mississippi River Birdsfoot Delta, Pass a Loutre, and the Barataria Bay Estuary (Bayou Jimmy) due to their close proximity to the spill. Mississippi, Alabama, and eastern Florida also received varying amounts of oil from the DWH event, but generally less than the Louisiana coast. In most cases offshore spills, unless catastrophic in nature (e.g.,

DWH event spill), are not expected to significantly damage any wetlands along the Gulf Coast. On July 27, 2010, an additional vessel collision with an abandoned wellhead within the Barataria Bay, Louisiana, resulted in a 16-km^2 (6-mi^2) spill that was contained (U.S. Dept. of Homeland Security, CG, 2010e). It must be noted that, even with offshore spills, the degree of coastal impact is a function of the source oil type (Macondo was a light oil), volume, and condition of the oil as it reaches shore, along with the season of the spill and the composition of the wetland plant community affected.

Proposed Action Analysis

Wetlands are generally more susceptible to contact by inshore spills, which have a low probability of occurrence from OCS-related activities. Inshore vessel collisions may release fuel and lubricant oils, and pipeline ruptures may release crude and condensate oil. An estimated 49-126 spills could occur in coastal waters from the CPA proposed action and its support operations over the 40-year life span (**Table 3-7**). Offshore oil spills are much less likely to contact these wetlands than are inshore spills because these areas are generally protected by barrier islands, peninsulas, sand spits, and currents. The probabilities of an offshore spill ≥1,000 bbl occurring and contacting environmental features are described in Chapter 4.3.1.8 of the Multisale EIS. Eight parishes in Louisiana have a chance of spill contact. For these parishes, the chance of an OCS offshore spill ≥1,000 bbl occurring and reaching the shoreline ranges from 1 to 15 percent as the result of the proposed action over its 40-year life. Plaquemines Parish has the largest probability (10-15%) of contact in the CPA. Weathering, wave action, and the use of offshore dispersants would reduce the amount of oil that would reach wetland areas and would result in minimal impacts.

Primary Impacts of Oil Spills

While there are concerns that offshore spills may contribute to wetland damage, the distance of these production facilities makes the probability of toxic oil to reach the coastal wetlands low. The toxicity of the spilled oil from offshore is greatly reduced or eliminated by weathering, wave action, and dispersants. The greatest threat to wetland habitat with regard to an oil spill is from an inland spill resulting from a vessel accident or pipeline rupture. These spills are a concern since they would be much closer to the wetland resource. While a resulting slick may cause some impacts to wetland habitat, the cleanup effort (equipment, chemicals, and personnel) can generate greater effects to the area. Associated foot traffic may work oil farther into the sediment than would otherwise occur. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. Added concerns or factors that influence the effect of an oil spill to wetlands are the fate (frequency and weathering) and behavior of oil, air pollution, availability and adequacy of containment and cleanup technologies, and impacts of various oil-spill cleanup methods.

Numerous investigators have studied the immediate impacts of oil spills on Gulf wetland habitats and other wetland habitats elsewhere similar to those affected by OCS activities. Often, seemingly contradictory conclusions are generated from these impact assessments. These contradictions can be explained by differences in many parameters, including oil concentrations and chemical composition, vegetation type and density, season or weather, preexisting stress level on the vegetation, soil types, and water levels. Data suggest that vegetation that is lightly oiled will experience plant die-back, followed by recovery without replanting; therefore, most impacts to vegetation are considered to be short term and reversible (Lytle, 1975; DeLaune et al., 1979; Webb et al., 1985; Alexander and Webb, 1987; Fischel et al., 1989).

Shoreline types have been rated via the ESI's, and according to their expected retention of oil and some biological effects, they exhibit oil persistence (Hayes et al., 1980; Irvine, 2000). Oil has been found or estimated to persist for at least 17-20 years in low-energy environments like salt marshes (Teal et al., 1992; Baker et al., 1993; Burns et al., 1993; Irvine, 2000). In some instances, where there has been further damage due to cleanup activities, recovery has been estimated to take from 8 to 100 years (Baca et al., 1987). Effects on marsh vegetation can be severe (Baca et al., 1987; Baker et al., 1993). The long-term recovery times occurred in nutrient-limited, colder environments where biodegradation is limited. But, those conditions are unlike the nutrient-rich marshes of the Gulf Coast. An effect from the depletion of marsh vegetation is increased erosion, which is of special concern to coastal Louisiana and parts of

coastal Texas. Cleanup activities in marshes that can last years to decades following a spill may accelerate erosion rates and retard recovery rates.

The critical concentration of oil is that concentration above which impacts to wetlands would be long term, because recovery would take longer than two growing seasons, and which causes plant mortality and permanent wetland loss. In coastal Louisiana, the critical concentration of oil resulting in long-term impacts to wetlands is assumed to be 0.1 $l/^2$ (0.026 gal/10.76ft^2). Concentrations less than this typically cause dieback of the aboveground vegetation for one growing season, but limited mortality. As discussed in Chapter 4.4.3.2 of the Multisale EIS, higher concentrations would cause mortality of contacted vegetation, but 35 percent of the affected area would recover within 4 years. Oil can persist in the wetland soil for at least 5 years. After 10 years, permanent loss of 10 percent of the affected wetland area can be expected from accelerated landloss indirectly caused by a spill. If a spill contacts wetlands exposed to wave action, additional and accelerated erosion will occur (Alexander and Webb, 1987). Louisiana wetlands are assumed to be more sensitive to oil contact than elsewhere in the Gulf because of high cumulative stress.

Because OCS-related pipelines traverse wetland areas, pipeline accidents could result in high concentrations of oil directly contacting localized areas of wetland habitats (Fischel et al., 1989). The fluid nature of the oil, water levels, weather, and the density of the vegetation would limit the area of interior wetlands contacted by any given spill. Other studies have noted that oil is more persistent in anoxic sediments and, as a result of this longer residence time, have the potential to do damage to both marsh vegetation and associated benthic species. The sediment type, the anoxic condition of the soils, and whether the area is in a low- or high-energy environment all play a part in the persistence of oil in marsh sediment (Teal and Howarth, 1984). Based on data from Mendelssohn et al. (1990), recovered vegetation is expected to be the ecologically functional equivalent of unaffected vegetation. This study tested the reduction in plant density as the principle impact from spills. Mendelssohn and his associates demonstrated that oil could persist in the soil for greater than 5 years if a pipeline spill occurs within the interior of a wetland where wave-induced or tidal flushing is not regular or vigorous (Mendelssohn et al., 1990). Since most of the wetlands along the Texas coast are either in moderate to high-energy environments, sediment transport and tidal stirring should reduce the chances for oil persisting in the event that these areas are oiled.

While oil can completely foul wetland plants, it is the amount and type of oil as well as the particular plant that determines recovery. Some studies (Pezeshki et al., 2000) found that the Louisiana crude was less damaging and fatal to *Spartina alterniflora* than the heavier crudes. Heavy oiling can stop photosynthetic activity, but the *S. alterniflora* produced additional leaves and was able to recover without shoreline cleanup. The experiment did note that *S. alterniflora* benefited and recovered more quickly after shoreline cleanup. Observations by Dr. White (personal communication, 2010) noted the same type of recovery with *Spartina* spp. in the Mississippi River Birdsfoot Delta after the marshes were oiled from the DWH event. Within several weeks of the oiling, there was production of new shoots and no indication of root damage. He attributes the success partly to no invasive cleanup procedures in the marsh, which could result in the compaction of the soils and cause oil to get into the root systems. Although the Louisiana Coast is more stressed as a result of oil development and hurricanes, it has a viable wetland fringe that is located in a well-flushed tidal environment. However, this wetlands ecosystem, which is not nutrient dependent, provides a great environment for biodegradation and flushing.

Secondary Impacts of Oil Spills

The short-term effects of oil on wetland plants range from reduction in transpiration and carbon fixation to plant mortality. Depending on the type and quantity of oil in the sediment, mineralization of nutrients can be blocked so there is less nutrient uptake from the soils. The potential impact of the oiling on the wetland habitats is dependent on several factors, including season, wetland (fresh, salt, or brackish), sediment type, oil type, and quantity and degree of oiling. In general, most wetland plants are more susceptible to impacts from oiling during the growing season. Heavy oil causes mortality by coating gas exchange surfaces on the plants and by sealing sediment, which limits nutrient exchange to below-ground tissue. Light weight oils have been found to be more toxic to the marsh plants and associated organisms because the oil alters membrane permeability and disrupts metabolism (Pezeshki et

al., 2000). Due to the difference in oil tolerances of various wetland plants, changes in species composition may be evident as a secondary impact of the spill (Pezeshki et al., 2000). Studies indicated that some dominant freshwater marsh species (*Sagittaria lancifolia*) are tolerant to oil fouling and that some may recover without being cleaned (Lin and Mendelssohn, 1996). Even though some species recover from fouling without being cleaned and others benefit from cleaning (Pezeshki et al., 2000), other studies by Mendelssohn et al. (1990 and 1993) noted that the plant composition in an oiled marsh can be changed post-spill as a result of plant sensitivity to oil. So, there can be a trade off from the disturbance within these wetlands resulting from workers gaining access to the plants by foot or boat and the potential benefits of cleaning. The compaction of the soil, in combination with the oiling, may further stress the plants and result in grater mortality (Pezeshki et al., 1995).

In a study by Mendelssohn et al. (1993) of a coastal pipeline break, low dosages of Louisiana crude (0.3 m^2 or 3 ft^2 marsh coverage) resulted in considerable short-term effects on the brackish marsh community. These effects were due to wind and high water conditions. Winds increased water levels in the marsh and resulted in a more complete oiling of both stems and leaves, which caused a 64 percent decrease in adjacent vegetation live cover. While considerable die out of the marsh was noted, recovery of the marsh was complete within 5 years despite the residual hydrocarbons that were found in the marsh sediment (Mendelssohn et al., 1993). As noted in other studies and Mendelssohn et al. (1993), the season and wind direction at the time of a spill can increase the potential impact to wetlands. The study also noted that the health of the recolonizing vegetation was not significantly different from the health of vegetation found in the areas that were not oiled. Patterns of landloss were spatially variable but the rate of loss was no different than the unaffected areas. It appears that in areas of incomplete recovery the low soil elevation, coupled with subsidence, made them more susceptible to frequent flooding prior to the spill. In addition, the soil elevations were further compacted and elevation lowered by the heavy machinery used in the cleanup operations (Mendelssohn et al., 1993).

As noted earlier, cleanup of these sensitive wetland habitats can be more disruptive and sometimes damaging than the oiling incident itself. Following the DWH event, USEPA and the USCG National Incident Command held a technology workshop and established an Interagency Alternative Technology Assessment Program (IATAP). This IATAP included numerous Federal agencies and local marsh ecologist with expertise concerning oil-spill cleanup to determine the least damaging approach to oil cleanup in these fragile coastal environments (U.S. Dept. of Homeland Security, CG, 2010d). The IATAP group reviewed various methods of response that could be used in areas that, based on hydrologic modeling, would receive oil. Current methods to clean up oil spills include mechanical and chemical removal, in situ burning, and bioremediation. The IATAP work group reviewed these and other mitigating measures specifically for areas where the vegetation had already been oiled. The IATAP recommended to keep the oil offshore and out of the marshes as long as possible, to not use actions that would further drive oil into the sediment (e.g., vessel and foot traffic), to not burn oil-contaminated vegetation if the water depth is insufficient or if there is the potential for re-oiling (this may result in root damage), to not apply dispersants in the marsh, to not use high-pressure washing that could drive oil deeper in sediments, to not hand clean vegetation (utilize low-pressure flushing if possible), and to monitor the utilization of sorbent booms. Bioremediation recommendations from the group were to minimize or eliminate vessel and foot traffic; mechanical removal methods should not disturb the substrate. Consideration was given to using nutrients and bacteria or fungi to enhance biodegradation. However, since the Gulf Coast is not nutrient limited, it was not determined to be useful. Two crucial points made by IATAP workgroup were (1) the use of particular cleanup methods is situation-dependent and (2) in the case of marshes it was best to do nothing and let nature take its course. The cleanup of oil spills in coastal marshes remains a problematic issue because wetlands can be extremely sensitive to the disturbances associated with cleanup activities. Once a marsh is impacted by an oil spill, a decision must be made concerning the best method of cleanup and restoration. Often the best course of action is to let the impacted area(s) recover naturally in order to avoid secondary impacts associated with the cleanup process, such as trampling vegetation, accelerating erosion, and burying oil (McCauley and Harrel, 1981; Long and Vandermeulen, 1983: Getter et al., 1984; Baker et al., 1993; Mendelssohn et al., 1993).

Summary and Conclusion

Offshore oil spills resulting from the CPA proposed action are not expected to significantly damage any wetlands along the Gulf Coast. This is because of the distance from the spill to the coast and because wetlands are generally protected by barrier islands, peninsulas, sand spits, and currents. Although the probability of occurrence is low, the greatest threat from an oil spill to wetland habitat is from an inland spill as a result of a vessel accident or pipeline rupture. Wetlands in the northern Gulf of Mexico are either in moderate- to high-energy environments, so sediment transport and tidal stirring should reduce the chances for oil persisting in the event that these areas are oiled. While a resulting slick may cause minor impacts to wetland habitat and surrounding seagrass communities, the equipment, chemical treatments, and personnel used to clean up can generate the greatest impacts to the area. Associated foot traffic may work oil farther into the sediment than would otherwise occur. Close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. In addition, an assessment of the area covered, oil type, and plant composition of the wetland oiled should be made prior to choosing remediation treatment. These treatments could include mechanical and chemical techniques with onsite technicians. Overall, impacts to wetland habitats from an oil spill associated with activities related to the CPA proposed action would be expected to be low and temporary because of the nature of the system, regulations, and specific cleanup techniques.

4.1.1.4.4. Cumulative Impacts

A detailed description of cumulative impacts upon wetlands can be found in Chapter 4.5.3.2 of the Multisale EIS and in Chapter 4.1.3.2.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Background/Introduction

Impacts from residential, commercial, and agricultural and silvicultural (forest expansion) developments are expected to continue in coastal regions around the Gulf. Existing regulations and development permitting procedures indicate that development-related wetland loss may be slowed and that 3-18 new onshore pipeline facilities, other than pipelines (26-39 landfalls), will be constructed in wetlands for the estimated life time (40 years) of the proposed action (Table 4-9 of the Multisale EIS). Impacts from State onshore oil and gas activities are expected to occur as a result of dredging for new canals, maintenance, and usage of existing rig access canals and drill slips, and preparation of new well sites. Locally, subsidence may be due to the extraction of large volumes of oil and gas from subsurface reservoirs, but subsidence associated with this factor seems to have slowed greatly over the last three decades as the reservoirs are depleted. However, recent reexamination of subsidence mechanisms by Stephens (2010b) states that the "Northern Gulf of Mexico continental margin is segmented by northwest-southeast trending transfer fault zones related to Mesozoic rifting." Indirect impacts from dredging new canals for State onshore oil and gas development (Chapter 4.1.3.3.3 of the Multisale EIS) and from the maintenance of the existing canal network is expected to continue. Maintenance dredging of the OCS-related navigation channels accounts for 10 percent of the dredged material produced.

Insignificant adverse impacts upon wetlands from maintenance dredging are expected because the large majority of the material would be disposed upon existing disposal areas. Alternative dredged-material disposal methods can be used to enhance and create coastal wetlands. Depending upon the regions and the soils through which they were dredged, secondary adverse impacts of canals may be more locally significant than direct impacts. Additional wetland losses may be generated by the secondary impacts of saltwater intrusion, flank subsidence, freshwater-reservoir reduction, and deeper tidal penetration. A variety of mitigation efforts have been initiated to protect against direct and indirect wetland loss. The nonmaintenance of mitigation structures that reduces canal construction impacts can have substantial impacts upon wetlands. These localized impacts are expected to continue. Various estimates of the total, relative direct, and indirect impacts of pipeline and navigation canals on wetland loss vary enormously; they range from estimates of 9 percent (Britsch and Dunbar 1993) to 33 percent (Penland et al., 2001a and 2001b) to estimates of greater than 50 percent (Turner et al., 1982; Scaife et al., 1983; Bass and Turner, 1997). A panel review of scientific evidence suggests that wetland losses directly

from human activities account for less than 12 percent of the total wetland loss experienced since 1930 and approximately 29 percent of the total losses between 1955 and 1978 (Boesch et al., 1994). Of these direct losses, 33 percent are attributed to canal and spoil bank creation (10% of overall wetland loss). In Louisiana, deepening the Fourchon Channel to accommodate larger OCS-related service vessels has occurred within a saline marsh environment and provides the opportunity to create wetlands with the dredged materials. In addition, installation and improvement of channel armor along the Port Fourchon channel and the enforcement of vessel speed and "no wake zones" should greatly reduce the loss of wetlands due to erosion and vessel traffic.

The main factors that continually affect wetlands from OCS activities are dredging, navigation channels and canals, pipelines, oil spill, and development of wetlands. The following is a summary of these effects on the wetlands and how the proposed action would not add significant negative effects to wetlands.

Dredging of Channels

There are 10 Federal channels totaling 2,000 km (1,243 mi) that are used in support of OCS activities (Chapter 4.5.3.2 of the Multisale EIS). Out of the 10 channels, 7 are shallow-water channels and 3 are deep-draft channels. All the channels will continue to require some form of maintenance dredging. The dredging cycle can range from 1 to 6 years, depending on channel or channel segment. Secondary wetland loss will continue throughout the 40-year project life because of canal widening resulting from erosion, saltwater intrusion, or a combination of the two. The extent of the losses depends on the future construction of channel stabilization features, hurricane activity, and increase in vessel use. The DOI has used a widening rate for OCS-related channels of 1.5 m/yr (4.9 ft/yr) (Chapter 4.5.3.2 of the Multisale EIS). Using the 2,000 km (1,243 mi) of estimated OCS-related channel length and the 1.5 m/yr (4.9 ft/yr) estimated bank widening rate, an annual landloss of ~300 ha/yr (741 ac/yr) could occur. So, in the 40-year cumulative activities scenario, landloss from indirect impacts of Federal navigation channels could be ~12,000 ha (29,653 ac). These numbers are likely overestimates of losses since different erosion rates for armored channels are not considered. More recent studies by USGS found that canal widening rates have slowed rather than increased in recent years as a result of increased bank stabilization efforts (Johnston et al., 2009). The results of a recently completed study that included both armored and unarmored canals supports the hypothesis that there are reduced loss rates along armored canals (Johnston et al., 2009; Thatcher et al., 2011). Information about these rates and the results of the Thatcher et al. (2011) study are discussed in **Chapter 4.1.1.4.2**.

Depending upon the regions and soils through which they were dredged, secondary adverse impacts of canals may be more locally significant than direct impacts. The OCS activities are expected to result in some level of dredging activity associated with the expansion of offshore platforms or onshore transfer or production facilities if needed. The primary indirect impacts from dredging would be wetland loss as a result of saltwater intrusion or vessel-traffic erosion. However, the primary support, transfer, and production facilities used for the CPA proposed action are located along armored canals and waterways, thus minimizing marsh loss. In the foreseeable future, there will be a continuing need for dredged material for both coastal restoration, wetland creation, and to some extent offshore sediments (e.g., sand, etc.) needed for beach restoration and hurricane protection. Alternative dredged-material disposal methods can be beneficially used for wetland creation or restoration as required by COE permitting program.

It is also noted that the DWH event spill exposed both inland and offshore navigation channels to treated oil that may now be located on the bottom of the channel. Exact locations, quantities, and condition of the oil resulting from the DWH event are not currently known but will be made publicly available as the assessment process progresses and analyses are completed. Dredging in these areas could resuspend remnant oil, but this oil is not expected to be toxic. This is because of dispersant treatment, weathering, and natural biodegradation that occurred.

The CPA proposed action is expected to use existing navigation channels and to contribute minimally to the need for additional channel maintenance. Impacts from State onshore oil and gas activities are expected to occur as a result of dredging for new canals, maintenance, and usage of existing rig access canals and drill slips, and preparation of new well sites. Insignificant adverse impacts upon wetlands from maintenance dredging are expected because the large majority of the material would be placed in

existing disposal areas or use alternate bank disposal techniques. The alternate bank disposal technique creates gaps to maintain hydrological connections and tidal circulation important in maintaining a functioning wetland.

Navigation Channels and Canals

The effects of pipelines, canal dredging, on navigation activities on wetlands are described in Chapters 4.1.2.1 and 4.2.2.1.3.2 of the Multisale EIS. Subsidence of wetlands is discussed in more detail in Chapter 4.1.3.3.1 of the Multisale EIS.

As noted in the referenced chapters above, the previous OCS activities associated with the CPA are expected to require some level of dredging, channel deepening, and maintenance of access canals. Onshore activity that would further accelerate wetland loss includes additional construction of access channels, and drill slips and onshore action needed for construction of new well sites and expansion or construction of onshore and offshore facilities (production platforms or receiving and transfer facilities). Management activities, including erosion protection and restoration along the edges of these canals, can significantly reduce canal-widening impacts on wetland loss (Johnston et al., 2009; Thatcher et al., 2011). These and similar studies are discussed in detail in **Chapter 4.1.1.4.2**. Impacts resulting from activities related to navigation canals can be mitigated with bank stabilization, enforcement of no wake zones, and where possible, the beneficial use of dredged material (produced during maintenance dredging activities) to create wetland or upland habitats. The service vessels associated with the CPA proposed action would generate an estimated 137,000-220,000 trips annually, which is 2-3 percent of the total OCS traffic (12% of all vessel traffic) generated in the GOM. Based on these estimates, the vessel-induced erosion associated with the proposed action is minimal. Therefore, marsh loss resulting from the combination of vessel-induced erosion and saltwater intrusion from navigation channels and canals is unlikely.

Pipelines

Modern pipeline installation methods and impacts are described in Chapters 4.1.1.8.1 and 4.1.2.1.7 of the Multisale EIS. While impacts are greatly reduced by mitigation techniques, expansion of tidal influence, saltwater intrusion, hydrodynamic alterations, erosion, sediment transport, and habitat conversion can still occur (Cox et al., 1997; Morton, 2003; Ko and Day, 2004b). The majority (over 80%) of OCS-related direct landloss is estimated to be from pipelines (Turner and Cahoon, 1988). Since the beginning of OCS activities in the GOM, approximately 15,400 km (9,563 mi) of pipelines have been constructed in Louisiana. These are seaward of the inland CZM boundary to the 3-mi State/Federal boundary offshore. Of those pipelines, about 8,000 km (4,971 mi) cross wetland and upland habitat. The remaining 7,400 km (4,595 mi) cross waterbodies (Johnston et al., 2009). The total length of non-OCS pipelines through wetlands is believed to be approximately twice that of the Gulf OCS Program, or about 15,285 km (9,492 mi). There is a total of approximately 23,285 km (14,460 mi) of pipelines through Louisiana coastal wetlands. The majority of OCS pipelines entering State waters ties into existing pipeline systems and does not result in new landfalls. Pipeline maintenance activities that disturb wetlands are very infrequent and are mitigated to the maximum extent practicable.

The widening of OCS pipeline canals does not appear to be an important factor contributing to OCS-related direct landloss. This is because few pipelines are open to navigation, and the impact width does not appear to be significantly different from that for open pipelines closed to navigation. Based on the projected coastal Louisiana wetlands loss of 132,607 ha (327,679 ac) for the years 2000-2040 (Barras et al., 2003), landloss resulting from new OCS pipeline construction represents <1 percent of the total expected wetlands loss for that time period (Chapter 4.5.3.2 of the Multisale EIS). This estimate does not take into account the present regulatory programs and modern installation techniques. Recently built pipelines and pipeline canals are much narrower than in the past because of advances in technology and improved methods of installation. These advances are due to a greater awareness among regulatory agencies and industry (Johnston et al., 2009). The magnitude of impacts from OCS-related pipelines is inversely proportional to the quantity and quality of mitigation techniques applied. Pipelines with extensive mitigation measures appeared to have minimal impacts, while pipelines without such measures attributed to significant habit changes. Through proper construction methods, mitigation and maintenance, impacts can be minimized or altogether avoided. The BOEMRE is not a permitting agency of onshore pipelines. The permitting agency would be COE and the State in which the activity has or

would occur. Therefore, it would be the responsibility of COE and the States to ensure that wetland impacts resulting from pipeline construction are properly mitigated and monitored.

Oil Spills

The potential for coastal/inland oil spills will continue. This creates the greatest concern for coastal wetlands due to the spill's proximity to these vegetated areas. The potential for vessel contact with improperly marked and abandoned wells in State nearshore waters will continue to increase until adequate funding is provided to monitor and inspect wells for compliance with procedures and regulations governing abandoned wells. The recent Barataria Bay spill (July 27, 2010) from an abandoned well in State waters released an estimated total of 7,000 gallons of oil and approximately 2,000 Mcf of natural gas per day (Powell, 2010; U.S. Dept. of Homeland Security, CG, 2010e). Aging infrastructure, including both platforms and pipelines, will continue to be an increasingly potential source of both inland and offshore spills. Over 3,000 production platforms in the Gulf are over 20 years old and were constructed prior to the modern structural requirements that increase endurance to hurricane force winds (Casselman, 2010). Earlier studies (Pulsipher et al., 1998) found that the age of a platform significantly affects the risk of an oil-spill accident during the exploration and production operations. Older pipelines are more susceptible to leaks through corrosion. As a result of how the older pipelines are constructed, these pipelines cannot be monitored or periodically inspected for potential leaks or pipeline weakness with modern, high-monitoring devices; therefore, the potential for preventing a potential leak is small. The potential for onshore and nearshore spills may decrease as a result of more stringent regulations and new policies that call for increased enforcement to address properly plugging and dismantling abandoned wells.

Offshore spills are less likely to reach the coastal wetlands in a fully toxic condition due to weathering and the blockage of spills by barrier islands. However, any reduced elevation and erosion of these barrier islands by Hurricanes Katrina and Rita decrease the level of protection afforded the mainland (USDOC, NMFS, 2007a). Flood tides may now bring some oil through tidal inlets into areas landward of barrier beaches. The turbulence of tidal water passing through most tidal passes would break up the slick, thereby accelerating dispersion and weathering. For the majority of these situations, light oiling of vegetated wetlands may occur. This oil contributes less than 0.1 l/m^2 (0.026 gal/10.76 ft^2) on wetland surfaces. Any adverse impacts that may occur to wetland plants are expected to be very short lived, probably less than 1 year. The OCS spills could occur as a result of pipeline accidents and barge or shuttle tanker accidents during transit or offloading. The frequency, size, distribution, and impacts of OCS coastal spills are provided in Chapter 4.3.1.7 of the Multisale EIS. Non-OCS spills can occur in coastal regions as a result of import tankers, coastal oil production activities, and petroleum product transfer accidents. Their distribution is believed to be similar to that described in Chapter 4.3.1 of the Multisale EIS. Numerous wetland areas have declined or have been destroyed as a result of oil spills caused by pipeline breaks or tanker accidents.

The oil stresses the wetland communities, making them more susceptible to saltwater intrusion, drought, disease, and other stressors (Ko and Day, 2004b). Spills that occur in or near Chandeleur or Mississippi Sounds could affect wetland habitat in or near the Gulf Islands National Seashore and the Breton National Wildlife Refuge and Wilderness Area. Because of their natural history, these areas are considered areas of special importance. They also support endangered and threatened species. Although the wetland acreage on these islands is small, the wetlands make up an important element in the habitat of the islands. This area was severely impacted by Hurricane Katrina in August 2005. The inlets that connect Mississippi Sound with the marsh-fringed estuaries and lagoons within the islands are narrow, so a small percentage of the oil that contacts the Sound side of the islands would be carried by the tides into interior lagoons. The past discharge of saltwater and drilling fluids associated with oil and gas development has been responsible for the decline or death of some local marshes (Morton, 2003). Discharging OCS-related produced water into inshore waters has been discontinued, and all OCS-produced waters transported to shore are either injected or disposed of in Gulf waters and would not affect coastal wetlands (Chapter 4.1.1.4.2 of the Multisale EIS).

The numbers and sizes of coastal spills are presented in Table 4-13 of the Multisale EIS. About 95 percent of these spills are projected to be from non-OCS-related activity. Of coastal spills <1,000 bbl, the assumed size is 5 bbl; therefore, the great majority of coastal spills would affect a very small area and

dissipate rapidly. The small coastal spills that do occur from OCS-related activity would originate near terminal locations in the coastal zones of Texas, Louisiana, Mississippi, and Alabama, but primarily within the Houston/Galveston area of Texas and the deltaic area of Louisiana. An average of nine large (≥10,000 bbl) offshore spills is projected to occur annually in the CPA from all OCS sources over a 40-year scenario (Table 4-15 of the Multisale EIS). Of these offshore spills, one is estimated to occur every year from the Gulfwide OCS Program (Table 4-13 of the Multisale EIS). A total of 1,000-1,200 smaller (<1,000 bbl) offshore spills are projected annually from the OCS Program Gulfwide (Table 4-13 of the Multisale EIS). Chapter 4.3.1 of the Multisale EIS describes projections of future spill events in more detail. The OCS-related spills in the Gulf are expected to cause relatively small effects to fish resources, and they are discussed in Chapter 4.4.10 of the Multisale EIS.

The DWH event was the largest spill recorded in the GOM and resulted in the oiling of most of the Gulf Coast shoreline from the Louisiana/Texas State line to northwest Florida. This event must be considered in the cumulative baseline due to the volume of oil released and the geographic area affected. However, unlike other historic large spills (*Exxon Valdez* and *Ixtoc*), the oil was released and treated in deep water nearly 97 km (60 mi) from shore, and the spill occurred in an unconfined open ocean as opposed to a sheltered embayment. All of these factors contribute to the weathering and detoxification of the oil that reached the shoreline. It is too early to determine the cumulative long-term effect, if any, of this spill on the ongoing marsh loss or the acceleration of that loss. The current view of most wetland scientists in the area is that, due to the minimal penetration into the marsh, the weathered condition of the oil, and the observed resiliency of the marsh plants to oiling, the overall effect would be minor and recovery of some marsh vegetation is already being seen (Burdeau and Collins, 2010; Mascarelli, 2010; Zabarenko, 2010). While catastrophic spills could occur in the future as a result of human error, new regulations focusing on improved safety, more regulatory checks, and inspections should decrease the already small likelihood of the occurrence of such spills.

Development of Wetlands

The development of wetlands for agricultural, residential, and commercial uses will continue with more regulatory and planning constraints. Wetland damage would be minimized through the implementation of CZM guidelines, COE regulatory guidelines for wetland development, and various State and Federal coastal development programs. Examples of these programs are the Coastal Impact Assistance Program (CIAP), the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), and LACPR.

The past discharge of saltwater and drilling fluids associated with oil and gas development has been responsible for the decline or death of some marshes (Morton, 2003). Discharging OCS-related produced water into inshore waters has been discontinued, and all OCS-produced waters transported to shore would either be injected or disposed of in Gulf waters and would not affect coastal wetlands (Chapter 4.1.1.4.2 of the Multisale EIS). Dredged material would be deposited either in existing approved discharge sites or would be used beneficially for wetland restoration or creation. In the Port Fourchon area, some of the existing areas being filled with dredged material may be used, if needed, for the expansion of oil production or support facilities.

Cumulative loss of wetlands has occurred as a result of both natural and anthropogenic events. Natural subsidence has caused wetland loss through compaction of Holocene strata (the rocks and deposits from 10,000 years ago to present). Human factors such as onshore oil and gas extraction, groundwater extraction, drainage of wetland soils, and burdens placed by buildings roads and levees have also caused wetland loss. Areas of local subsidence have also been correlated to the past extraction of large volumes of underground resources including oil, gas, water, sulfur, and salt (Morton, 2003; Morton et al., 2002 and 2005). There is increasing new evidence of the importance of the effect of sea-level rise (or marsh subsidence) as it relates to the loss of or changes in marshes, types of marsh, and plant diversity (Spalding and Hester, 2007). This study shows that the very structure of coastal wetlands would likely be altered by sea-level rise because community shifts would be governed by the responses of individual species to new environmental conditions. Flood control and channel training along the Mississippi River would continue to deprive the delta of the needed sediment required for the creation or maintenance of the existing wetlands. Another recent development that is presently being proposed along the Mississippi coast and is planned for the Louisiana and Texas coasts is the preparation of salt domes for the storage of

strategic oil reserves. The current plan would result in discharging highly concentrated salt solutions into the nearshore Gulf and bays. The potential for large modifications (increases) in coastal salinities could result in devastating or severely compromising the coastal marshes (Mississippi Press, 2007).

Following Hurricanes Rita and Katrina, the demand for large quantities of earthen construction materials for hurricane-protection levee construction or restoration resulted in either removing or damaging some marginal wetlands. It is expected that the need for these materials will continue in the future.

Summary and Conclusion

Wetlands are most vulnerable to inshore or nearshore oil spills but these are localized events. Spill sources include vessel collisions, pipeline breaks, and shore-based transfer, refining, and production facilities. The wetlands associated with the CPA proposed action have a minimal probability for oil-spill contact. This reduced risk is due to the distance of the offshore facility to wetland sites, beach and barrier island topography (although locally reduced post-Hurricanes Katrina and Rita), and product transportation through existing pipelines or pipeline corridors. Wetlands can also be at risk for offshore spills, but the risks are minimized by distance, time, sea conditions, and weather. If they do reach shore, only light localized impacts to inland wetlands would occur. If any inland spills occur, they would likely be small and at inland service bases or other support facilities and generally located away from wetlands; therefore, the spills would not be expected to affect wetlands.

While landloss will continue from subsidence and saltwater intrusion, the State of Louisiana and COE have implemented freshwater diversion projects to minimize the effect of this saltwater-induced landloss. Landloss would continue from vessel traffic; however, because of the small increase in traffic caused by the proposed action, this loss would also be minimal. The CPA proposed action would not require any channel maintenance; therefore, no additional wetland loss would result from dredged material disposal. If dredged-material disposal is required, it would likely be beneficially used for marsh creation. Disposal of OCS wastes and drilling by-products would be delivered to existing facilities. Because of existing capacity, no additional expansion into wetland areas is expected.

Development pressures in the coastal regions of Louisiana, Mississippi, Alabama, and Florida have caused the destruction of large areas of wetlands. In coastal Louisiana, the most destructive developments have been the inland oil and gas industry projects, which have resulted in the dredging of huge numbers of access channels. Agricultural, residential, and commercial developments have caused the most destruction of wetlands in Mississippi, Alabama and Florida. In Florida, recreational and tourist developments have been particularly destructive. These trends are expected to continue. During the period from 2001 to 2040, between 248,830 and 346,590 ha (614,872 and 856,443 ac) of wetlands would be lost from the Louisiana coastal zone and 1,600-2,000 ha (647-809 ac) would be lost from the Mississippi coastal zone. Wetland losses in the coastal zones of Alabama and Florida are assumed to be comparable with those in Mississippi. New and existing pipeline channels would continue eroding, largely at the expense of wetlands; however, channel armor may be added at a later date. However, these estimates do not take into account the current regulatory programs, modern construction techniques and mitigations, or any new techniques that might be developed in the future. Because of modern construction techniques and mitigation measures, there would be zero to negligible impacts on wetland habitats as a result of the CPA proposed action. The CPA proposed action represents a small percentage (<10%) of total OCS activity (USDOI, MMS, 2007b). Impacts associated with the CPA proposed action are a minimal part of the overall OCS impacts. The cumulative effects of human and natural activities in the coastal area have severely degraded the deltaic processes and have shifted the coastal area from a condition of net land building to one of net landloss. Deltaic Louisiana is expected to continue to experience the greatest loss of wetland habitat. Wetland loss is also expected to continue in coastal Mississippi, Alabama, and Florida, but at slower rates. The incremental contribution of the CPA proposed action to the cumulative impacts on coastal wetlands is expected to be small.

4.1.1.5. Seagrass Communities

The BOEMRE has reexamined the analysis for seagrass communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS (addition of 181 South Area) based on the additional information

presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for seagrass communities presented in the Multisale EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Turbidity impacts from pipeline installation and maintenance dredging associated with the CPA proposed action would be temporary and localized. The increment of impacts from service-vessel transit associated with the CPA proposed action would be minimal. Should an oil spill occur near a seagrass community, impacts from the spill and cleanup would be considered short term in duration and minor in scope. Close monitoring and restrictions on the use of bottom-disturbing equipment to clean up the spill would be needed to avoid or minimize those impacts. Of the cumulative activities, dredging generates the greatest overall risk to submerged vegetation, while hurricanes cause direct damage to seagrass beds, which may fail to recover in the presence of cumulative stresses. The CPA proposed action would cause a minor incremental contribution to cumulative impacts due to dredging from maintenance of channels.

4.1.1.5.1. Description of the Affected Environment

A detailed description of seagrass communities in the CPA (Louisiana, Mississippi, Alabama, and because of its close proximity to the CPA, Florida is discussed here) can be found in Chapter 4.2.2.1.3.3 of the Multisale EIS. Additional information regarding the additional 181 South Area and any new information found since the publication of the Multisale EIS is presented in Chapter 4.1.3.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

A search was conducted for new information published on submerged vegetation, and various Internet sources were examined to determine any recent information regarding seagrasses. Sources investigated include BOEMRE, USDOC/NOAA, the USGS National Wetlands Research Center, the USGS Gulf of Mexico Integrated Science Data Information Management System, Seagrass Watch, Gulf of Mexico Alliance, State environmental agencies, USEPA, and coastal universities. Other websites from scientific publication databases were checked for new information using general Internet searches based on major themes. New information is discussed below.

Submerged vegetation distribution and composition depend on an interrelationship among a number of environmental factors that include water temperature, depth, turbidity, salinity, turbulence, and substrate suitability (Kemp, 1989; Onuf, 1996; Short et al., 2001). Marine seagrass beds generally occur in shallow, relatively clear, protected waters with sand bottoms (Short et al., 2001). Freshwater submerged aquatic vegetation (SAV) species occur in the low-salinity waters of coastal estuaries (Castellanos and Rozas, 2001). True seagrasses that occur in the Gulf of Mexico are *Halodule beaudettei* (formerly *Halodule wrightii;* shoal grass), *Halophila decipiens* (paddle grass), *Halophila engelmannii* (star grass), *Syringodium filiforme* (manatee grass), and *Thalassia testudinum* (turtle grass) (Short et al., 2001; Handley et al., 2007). Although it is not considered a true seagrass because it has hydroanemophilous pollination (pollen grains float) and can tolerate freshwater, *Ruppia maritima* (widgeon grass) is common in the brackish waters of the Gulf of Mexico (Zieman, 1982; Berns, 2003; Cho and May, 2008). Freshwater genera that are dominant in the northern Gulf of Mexico are *Ceratophyllum*, *Najas*, *Potamogeton*, and *Vallisneria* (Castellanos and Rozas, 2001; Cho and May, 2008). Submerged vegetation increases protection from predation and food resources for associated nekton (Rozas and Odum, 1988; Maiaro, 2007). Seagrasses and freshwater SAV's provide important nursery and permanent habitat for sunfish, killifish, immature shrimp, crabs, drum, trout, flounder, and several other nekton species and provide a food source for species of wintering waterfowl and megaherbivores (Rozas and Odum, 1988; Rooker et al., 1998; Castellanos and Rozas, 2001; Heck et al., 2003; Orth et al., 2006). They also act in carbon sequestration, nutrient cycling, and sediment stabilization (Heck et al., 2003; Duarte et al., 2005; Orth et al., 2006). They are also substrate for epiphytes to grow, which can be a hindrance (shading) if too thick to the seagrass, but those epiphytes serve as another food source to different species (Howard and Short, 1986; Bologna and Heck, 1999).

According to the most recent and comprehensive data available, approximately 500,000 ha (1.25 million ac) of seagrass beds are estimated to exist in exposed, shallow coastal/nearshore waters and embayments of the Gulf of Mexico, and over 80 percent of these beds are in Florida Bay and Florida coastal waters (calculated from Handley et al., 2007). In the northern Gulf of Mexico from south Texas to Mobile Bay, seagrasses occur in relatively small beds behind barrier islands in bays, lagoons, and coastal waters (**Figure 4-3**); while SAV's occur in the upper freshwater regions of estuaries and rivers (Onuf, 1996; Castellanos and Rozas, 2001; Handley et al., 2007). Increased nutrients and sediments from either natural or anthropogenic events such as tropical cyclones and watershed runoff are common and significant causes of seagrass decline (Carlson and Madley, 2007). Recent increases in natural and anthropogenic stresses have led to decreases in these communities worldwide (Orth et al., 2006). The USGS's *Seagrass Status and Trend in the Northern Gulf of Mexico: 1940-2002* demonstrated a decrease of seagrass coverage from approximately 1.02 million ha (2.52 million ac) estimated in 1992 to approximately 500,000 ha (1.25 million ac) calculated in the 2002 report (Handley et al., 2007). While declines have been documented for different species in different areas, it is difficult to estimate rates of decrease because of the fluctuation of biomass among the different species, seasonally and yearly.

Louisiana: In Louisiana, submerged vegetation primarily consists of freshwater and low-salinity vegetation. Largely due to the turbid water conditions that are caused by the Mississippi and Atchafalaya Rivers, seagrass beds in Louisiana have low densities and are rare. The exceptions are the beds in the vicinity of the Chandeleur Island chain located between Louisiana and Mississippi (Poirrier, 2007). Many beds in Louisiana are continually affected by storm events of different severities throughout the year. Submerged vegetation is physically removed, buried, or exposed to drastic salinity shifts after severe storm events (Maiaro, 2007). The recovery times for beds depends on the size of the disturbance (Fourqurean and Rutten, 2004). Strong storm events not only remove seagrass and SAV beds but also change the nekton community structure (Maiaro, 2007). In Biloxi Marsh, southeast Louisiana, nekton communities at sites denuded of *R. maritima* by Hurricanes Cindy and Katrina resembled communities in sites that had no vegetation before the hurricanes (Maiaro, 2007). The seagrasses behind the Chandeleur Island chain and SAV communities within Plaquemines and St. Bernard Parishes had contact with the oil from the DWH event and had considerable physical stress from various prevention and cleanup efforts (USDOC, NOAA, 2010f). There is the potential for significant shifts in community structure, but the current health of the community in unknown. It is assumed there will be a decrease in submerged vegetation and a negative impact on the communities in the areas affected by the DWH event. There are ongoing research projects that will document effects of the spill and associated activities on local communities. This research also includes a study on the environmental effects from the oil barrier berms built in portions of southeastern Louisiana.

Mississippi: Seagrass beds primarily occur in the Mississippi Sound and are in the proximity of the Gulf Island National Seashore islands including Ship, Horn, Petit Bois, and Cat (Moncreiff, 2007). After local extinctions of *T. testudinum* and *S. filiforme* from Hurricane Camille and recent increases in freshwater outflow from nearby watersheds, there has been an increase in *R. maritima* and a persistence of *H. beaudettei*, making them the predominant submerged vegetation communities along the Mississippi coast (Cho and May, 2008; Cho et al., 2009; Barry A. Vittor and Associates, Inc., 2009). While submerged vegetation abundance decreased in 2005 after the passage of Hurricanes Cindy and Katrina, there was a documented increase in abundance in 2006 (Cho and May, 2008). Because *R. maritima* is known to be resilient to temporary disturbances, further studies confirmed a seasonal trend to percent cover changes in the Mississippi Sound (Cho and May, 2008). This resiliency could be an important factor in ecosystem health with events such as the DWH event. Mississippi Sound had oil slicks from the DWH event, and some beds within that area had contact with both tarballs and oil (USDOC, NOAA, 2010f). The current health of the system is unknown. If this area continues to accrue oil, then there is the hypothesis that there would be a decrease in seagrass cover and an adverse effect on the associated community. Research is being conducted to assess the effects from the event on the local submerged vegetation beds.

Alabama: Barry A. Vittor & Associates, Inc. (2009) reported approximately 2,100 ha (5,250 ac) of freshwater and marine submerged vegetation in Alabama coastal waters. They found there was a decrease in SAV cover in the southern portion of the study area in coastal Alabama from 2002 to 2009 by approximately 20 percent. Hurricanes Ivan and Katrina potentially influenced the local SAV communities with increased salinity, water turbidity, and scouring from storm surges (Barry A. Vittor &

Associates, Inc., 2009). However, there was no large-scale impact on the distribution or ecological performance of Alabama's marine seagrass beds from either Hurricane Ivan or Katrina (Byron and Heck, 2006; Anton et al., 2009). While oil and tarballs have impacted the barrier islands in coastal Alabama, any effect to the beds from the impact of the DWH event are unknown (USDOC, NOAA, 2010f). At this time, it is assumed that these communities are generally similar ecologically to what it was before the DWH event occurred. There are extensive sampling efforts underway throughout the Gulf of Mexico to assess any effects from the incident to different submerged vegetation beds.

Florida: There are an estimated 400,000 ha (1 million ac) of seagrasses in west Florida's nearshore coastal waters and Florida Bay (Carlson and Madley, 2007). Most of the seagrass coverage in Florida is in south Florida and the higher-salinity estuarine regions in the Florida Panhandle, between Pensacola and Alligator Harbor, and the Big Bend area (Dawes et al., 2004; Carlson and Madley, 2007; Carlson et al., 2010). The Big Bend area has low wave energy due to the shallow and gently sloping nature of the sea bottom, and these beds extend into Federal waters (CSA and Martel Laboratories, Inc., 1985; Zieman and Zieman, 1989). This area had declined by approximately 95,000 ha (234,750 ac) in 2001 to approximately 91,000 ha (224,866 ac) in 2006 (4.5%) in continuous seagrass coverage (Carlson et al., 2010). Throughout the west Florida shelf, there are seasonally patchy offshore beds of *H. decipiens* (Dawes et al., 2004). Many beds in Florida are protected by extensive barrier islands. These islands help protect the Florida coast from the many tropical cyclones that impact this State. However, the increased turbidity and freshwater from these storm events have decreased many areas of seagrass beds on the western coast of Florida (Carlson et al., 2010). The panhandle was exposed to oil and tarballs from the DWH event, but the majority of the seagrass beds in south Florida received little impact from the DWH event (USDOC, NOAA, 2010f). It is assumed these communities will be similar to how they were before the DWH event unless a significant delayed impact occurs. Florida has multiple sampling stations to examine any effects from the incident to submerged vegetation beds.

4.1.1.5.2. Impacts of Routine Events

Background/Introduction

The routine events associated with OCS activities in the CPA that could adversely affect submerged vegetation communities include construction of pipelines, canals, navigation channels, and onshore facilities; maintenance dredging; and vessel traffic (e.g., propeller scars). Many of these activities would result in an increase of water turbidity that is detrimental to submerged vegetation health. Through avoidance and mitigation policies, these effects are generally localized, short-term, and minor in nature. Existing and projected lengths of OCS-related dredging, pipelines, and vessel activities are described in detail in Chapters 4.1.2.1.7 and 4.1.3.3.3 of the Multisale EIS and in Chapter 3.1 of this Supplemental EIS. The dynamics of how these activities impact submerged vegetation is discussed in Chapters 4.2.1.1.3.3 and 4.2.2.1.3.3 of the Multisale EIS and are summarized here.

Proposed Action Analysis

Dredging impacts associated with the installation of new navigation channels are greater than those for pipeline installations because it creates a much wider and deeper footprint. New canal dredging and related disposal of dredged material also cause significant changes in regional hydrology (Onuf, 1994; Collins, 1995; Erftemeijer and Lewis, 2006). Examples of this are the heavy traffic utilizing the Gulf Intracoastal Waterway and maintenance dredging that decrease local seagrass beds in Laguna Madre, Texas (Texas Parks and Wildlife Department, 1999). Deepwater oil and gas exploration requires larger vessels that could cause channel widening; however, the inshore facilities would probably remain the same. In Louisiana, they are located in Cameron, Fourchon, Intracoastal, Morgan City, and Venice. In Mississippi, there is a shore base in Pascagoula, and in Alabama, the shore base is in Theodore. Channel dredging to facilitate, create, and maintain waterfront real estate, marinas, and waterways will continue to be a major impact-producing factor on the Gulf Coast. The waterway maintenance program of COE has been operating in the CPA for decades. Impacts generated by initial channel excavations are sustained by regular maintenance activities performed on average every 2-5 years. Maintenance activities are projected to continue into the future regardless of the OCS activities.

Dredge and fill activities are the greatest threats to submerged vegetation habitat (Wolfe et al., 1988). Effects from dredging and resuspension of sediments are relative to dredge type and sediment size (Collins, 1995). The most serious impacts generated by dredging activities to submerged vegetation and associated communities are a result of the removal of sediments, changes in salinity, burial of existing habitat, and oxygen depletion and reduced light associated with increased water turbidity (Erftemeijer and Lewis, 2006). Increased water turbidity from dredging operations that causes light attenuation negatively affects vegetation health (Onuf, 1994; Kenworthy and Fonseca, 1996). Suspension of the fine sediments from dredging activities may influence not only water clarity but also nutrient dynamics in estuaries, which can decrease overall primary production (Essink, 1999; Erftemeijer and Lewis, 2006). While these effects can decrease submerged vegetation cover, the activities would be localized and monitored events. Also, plans for installation of new linear facilities and maintenance dredging are reviewed by a variety of Federal, State, and local agencies and the interested public in order to receive the necessary government approvals. Mitigation may be required to reduce undesirable effects on beds from dredging activities. The most effective mitigation for direct impacts to submerged vegetation beds and associated communities is avoidance, but if contact is unavoidable then actions such as using turbidity curtains with a sizable barrier can mitigate dredge effects.

Pipeline construction in coastal waters could temporarily elevate water turbidity in submerged vegetation beds near the pipeline routes. The duration of increased water turbidity would depend on factors like currents, bottom topography, and substrate type (Collins, 1995). The COE and State permit requirements are expected to impose pipeline routes that avoid high-salinity beds, as well as reduce and maintain water turbidity within tolerable limits for submerged vegetation. About 250 active OCS pipelines currently cross the Federal/State boundary into State waters, of which over 100 make landfall. There are 80-118 new pipelines projected in State waters as a result of the OCS Program from 2007 to 2046. Of those, 26-39 are anticipated to make landfall in the CPA. Most activities would use existing inshore structures, so less than one pipeline a year would make landfall. If any new pipelines run to shore due to the CPA proposed action, environmental permit requirements for locating pipelines would result in minimal impact on seagrasses. Because of regular tidal flushing, increased water turbidity from pipeline activities is projected to be below significant levels. Therefore, effects on submerged vegetation by pipeline installation are predicted to be small and short term.

Vessel traffic would only pose a risk to seagrasses when near shore and to SAV when inshore. Submerged vegetation beds near active navigation channels would already be altered physically by regularly occurring associated activities. Because of the depths where major vessel traffic occurs, propeller wash would not resuspend sediments in navigation channels beyond pre-project conditions. Little, if any, damage to submerged vegetation beds would occur as a result of typical channel traffic. Scarring of seagrass beds by vessels (e.g., support vessels for OCS and State oil and gas activities, fishing vessels, and recreational watercraft) is an increasing concern along the Mississippi, Alabama, and Florida coasts (Sargent et al., 1995; USDOI, GS, 2004). Scarring most commonly occurs in water depths less than 2 m (~6 ft) as a result of boats operating in too shallow water (Zieman, 1976; Sargent et al., 1995; Dunton et al., 1998). Consequently, their propellers and occasionally their keels plow through vegetated bottoms tearing up roots, rhizomes, and whole plants, leaving a furrow that is devoid of submerged vegetation (Zieman, 1976; Dawes et al., 1997). This can ultimately destroy the beds, which are essential nursery habitat for many species (Heck et al., 2003; Orth et al., 2006). The recovery period from scarring varies with the width of the scar, type of scarring, sediment, water quality, and species (Zieman, 1976; Durako et al., 1992; Sargent et al., 1995). If a bed has extensive damage or an already stressed bed is damaged, it could take decades to recover. Scarring may have a more critical effect on habitat functions in areas with less submerged vegetation, like those found in Louisiana. The State of Florida has the Seagrass Outreach Partnership that consists of citizens, researchers, law enforcement officers, and marine resource managers. It was created to reducing boating impacts to seagrass meadows through education. Restoration efforts are funded through fines collected from boaters. There would be little reason for an OCS vessel to anchor or stop in areas that are not designated ports or work structures; therefore, it would be rare for these vessels to be in areas populated by vegetation. There would be little reason for an OCS vessel to anchor or stop in areas that are not designated ports or work structures; therefore, it would be rare for these vessels to be in areas populated by vegetation.

Summary and Conclusion

Routine OCS activities in the CPA are not expected to significantly increase in occurrence and range in the near future. Mitigation reduces the undesirable effects on submerged vegetation beds from dredging activities. Permit requirements should ensure pipeline routes avoid high-salinity beds and maintain water clarity and quality. Local programs decrease the occurrence of prop scarring in grass beds, and channels utilized by OCS vessels are generally away from exposed submerged vegetation beds. Because of these requirements, natural flushing, and implemented programs, any potential effects from routine activities on submerged vegetation in the CPA are expected to be localized and not significantly adverse.

4.1.1.5.3. Impacts of Accidental Events

Background/Introduction

A detailed analysis of accidental impacts upon seagrass communities can be found in Chapter 4.4.3.3 of the Multisale EIS and in Chapter 4.1.3.3.3 of the 2009-2012 Supplemental EIS. The following is a summary of that information and any new information discovered through recent literature searches since both documents were prepared.

Proposed Action Analysis

In Louisiana, submerged vegetation primarily consists of freshwater and low-salinity vegetation, but there are seagrass beds in the vicinity of the Chandeleur Island chain (Poirrier, 2007). Mississippi seagrass beds primarily occur in the Mississippi Sound and are in the proximity of the Gulf Island National Seashore islands (Moncreiff, 2007). Alabama's coast has submerged beds throughout the area. Most of the seagrass coverage in Florida is in south Florida and the higher-salinity estuarine regions in the Florida Panhandle, between Pensacola and Alligator Harbor, and the Big Bend area (Dawes et al., 2004; Carlson and Madley, 2007; Carlson et al., 2010). Accidental events possible with the CPA proposed action that could significantly adversely affect submerged vegetation beds include near and inshore spills connected with the transport and storage of oil. Offshore oil spills that occur in the proposed action area are less likely to contact seagrass communities than are inshore spills because the seagrass beds are generally protected by barrier islands, peninsulas, sand spits, and currents. However, if the temporal and spatial duration of the spill is massive, then an offshore spill could affect submerged vegetation communities as seen with the DWH event.

The probabilities of a spill ≥1,000 bbl occurring and contacting environmental features are described in Chapter 4.3.1.5 and Figure 4-12 of the Multisale EIS. The total estimated number of offshore spill events ranging from 0 to ≥10,000 bbl over the 40-year life of the CPA proposed action is 2,690-5,452 spills (**Table 3-5**; Chapter 4.3.1.5 of the Multisale EIS). The risk of an offshore spill ≥1,000 bbl occurring and contacting coastal counties and parishes was calculated by BOEMRE's oil-spill trajectory model. Counties and parishes are used as an indicator of the risk of an offshore spill reaching sensitive coastal environments, and this is the point when oil could contact the submerged community. Figure 4-14 of the Multisale EIS provides the results of the OSRA model that calculated the probability of a spill ≥1,000 bbl occurring offshore as a result of the proposed action and reaching a Gulf Coast county or parish.

Most of the counties and parishes are at minimum risk of being contacted; the most frequently calculated probability of a spill contacting their shorelines is less than 0.5 percent. Eight parishes in Louisiana have a chance of spill contact that is greater than 0.5 percent. For these parishes, the chance of an OCS offshore spill ≥1,000 bbl occurring and reaching their shoreline ranges from 1 percent to 15 percent. Plaquemines Parish, Louisiana, has the greatest risk of a spill occurring and contacting its shoreline. The probability of an oil spill ≥1,000 bbl contacting the State offshore waters within 10 days and contacting some submerged vegetation in the CPA for western Louisiana is 23-35 percent, eastern Louisiana is 6-9 percent, Mississippi is 1 percent, and it is less than 0.5 percent for all other states (Figure 4-15 of the Multisale EIS).

Inshore spills may result from either vessel collisions or ruptured pipelines that release crude and condensate oil. The coast from the Atchafalaya Bay to east of the Mississippi River in Louisiana has the

greatest risk of experiencing coastal spills related to the CPA proposed action (Chapter 4.3.1.7.2 of the Multisale EIS). Because of the floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amount of micro-organisms that consume oil, these spills would typically be short-term events and have little prolonged effects on vegetated communities and the associated fauna (DeLaune et al., 1990; Roth and Baltz, 2009). Increased water turbulence from waves, storms, or vessel traffic breaks apart the surface oil sheen and disperses some oil into the water column or mix the oil with sediments, which can settle and coat the entire plant with oil and sediments (Teal and Howarth, 1984; Thorhaug, 1988; Burns et al., 1994). This coating situation also happens when oil is treated with dispersants because the dispersants break down the oil and it sinks into the water column. However, as reviewed in Runcie et al. (2004), oil mixed with dispersants has shown an array of effects on seagrass depending on the species and dispersant used.

An offshore spill would inundate the coastal waters first and affect local communities similar to an inshore spill. With a greater distance from shore, there is a greater chance of the oil being weathered by natural and mechanical processes by the time it reaches the nearshore habitat.

If an oil slick settles into a protective embayment where submerged vegetation beds are found, decreased water clarity from coating and shading causes reduced chlorophyll production and could lead to a decrease in vegetation (Erftemeijer and Lewis, 2006). Depending on the species and environmental factors (e.g., temperature and wave action), seagrasses may exhibit minimal impacts from a spill; however, communities residing within the beds could accrue greater negative outcomes (den Hartog and Jacobs, 1980; Jackson et al., 1989; Kenworthy et al., 1993; Taylor et al., 2006). Community effects could range from direct mortality due to smothering or indirect mortality from loss of food sources and habitat to a decrease in ecological performance of the entire system depending on the severity and duration of the spill event (Zieman et al., 1984). Because different species have different levels of sensitivity to oil, it is difficult to compare studies and extrapolate what variables caused the documented differences in vegetation and community health (Thorhaug et al., 1986; Runcie et al., 2004).

Prevention and cleanup efforts could also affect the health of submerged vegetation communities (Zieman et al., 1984). Many physical prevention methods such as booms, barrier berms, and diversions can alter hydrology specifically changing salinity and water clarity. These changes would harm seagrasses because they are tolerant to certain salinities and light levels (Zieman et al., 1984; Kenworthy and Fonesca, 1996). There is increased boat and human traffic in these sensitive areas that generally are protected from this degree of human disturbance prior to the response. Increased vessel traffic would lead to elevated water turbidity and increased prop scarring. While the elevated levels of water turbidity would be short-term and the possible damages from propellers could be longer, both events would be localized during the prevention and cleanup efforts (Zieman, 1976; Dawes et al., 1997). Detailed sampling to evaluate the effects of the DWH event and associated prevention/cleanup efforts are occurring within the NRDA process. The information that is currently available about the current state of the submerged vegetation from Louisiana, Mississippi, Alabama, and Florida are found in **Chapter 4.1.1.5.1**.

Summary and Conclusion

Although the probability of their occurrence is low, the greatest threat to inland, submerged vegetation communities would be from an inland spill resulting from a vessel accident or pipeline rupture. The resulting slick may cause short-term and localized impacts to the submerged vegetation bed. There is also the remote possibility of an offshore spill to such an extent that it could also affect submerged vegetation beds, and this would have similar effects to an inshore spill. Because prevention and cleanup measures can have negative effects on submerged vegetation, close monitoring and restrictions on the use of bottom-disturbing equipment would be needed to avoid or minimize those impacts. The floating nature of nondispersed crude oil, the regional microtidal range, dynamic climate with mild temperatures, and the amount of microorganisms that consume oil would alleviate prolonged effects on submerged vegetation communities. Also, safety and spill-prevention technologies continue to improve and will decrease detrimental effects to submerged vegetation from the proposed action.

4.1.1.5.4. Cumulative Impacts

A detailed impact analysis for cumulative impacts in the CPA on submerged vegetation can be found in Chapter 4.5.3.3 of the Multisale EIS and in Chapter 4.1.3.3.4 of the 2009-2012 Supplemental EIS. The following is a summary and incorporates any new information that has become available since both documents were prepared. Of all of the activities in the cumulative scenario found in **Chapter 3.3** of this Supplemental EIS, dredging, oil spills/pipelines, hydrological changes, and storm events present the greatest threat of impacts to submerged vegetation communities.

Background/Introduction

Generally dredging generates the greatest overall risk to submerged vegetation by uprooting and burying plants, decreasing oxygen in the water, and reducing water clarity in an area. Increased dredging in the CPA is expected only in areas that do not support submerged vegetation beds. Maintenance dredging would not have a substantial effect on existing seagrass habitat given that no new channels are expected to be dredged as a result of OCS activities in the CPA. Another anthropogenic activity that could cause adverse effects to submerged vegetation is accidental oil-spill events. These are generally rare and small-scale, but they do add to the possible cumulative damage to the submerged vegetation systems. Finally, historic and some recent construction of structures like levees and berms change local hydrology and that effects submerged vegetation beds. There has also been an increase in tropical cyclone events in the Atlantic. Hurricanes generate substantial overall risk to submerged vegetation by burial and eroding channels through seagrass beds. When combined with other stresses, impacted seagrass beds may fail to recover.

In support of inshore petroleum development, the oil and gas industry and land developers perform most of the dredging that impacts lower salinity submerged vegetation in Louisiana and Texas. Mitigation may be required to reduce undesirable impacts of dredging to submerged vegetation. Maintenance dredging of navigation channels help sustains the impacts of original dredging. From 2007 to 2046, offshore oil and gas activities are projected to generate 25-36 pipeline landfalls in Louisiana and 1-3 pipeline landfalls for Mississippi and Alabama collectively (Table 4-9 of the Multisale EIS). Those numbers are equivalent to approximately one pipeline a year. The most effective mitigation for direct impacts to submerged vegetation beds is avoidance, but there are other mitigation techniques in place to lessen the effects from unavoidable disturbances.

Inshore oil spills generally present a greater risk of adversely impacting submerged vegetation and seagrass communities than do offshore spills with regards to OCS activities in the CPA. However, if an offshore spill is of large magnitude like that of the DWH event, then oil could make contact with and have similar effects to submerged vegetation beds as an inshore spill. Although little to no direct permanent mortality of seagrass beds is expected as a result of oil-spill occurrences, contact of seagrasses with crude and refined oil has been implicated as a cause of the decline in plant biomass and cover, and a cause of the observed changes in species composition within them (Zieman et al., 1984; Erftemeijer and Lewis, 2006). Because nondispersed oil floats and because of the local microtidal range, oil spills alone would typically have little impact on submerged vegetation beds and associated epifauna. During and after a spill event, the cleanup effort can cause significant scarring and trampling of submerged vegetation beds with increased traffic in the area. Also, preventative measures (booms, berms, and diversions) can alter water hydrology and salinity, which could harm the beds and their associated communities.

Many of man’s activities have caused landloss either directly or indirectly by accelerating natural processes. Floodwaters layered sediment over the active Mississippi River deltaic plain, and this accretion countered ongoing submergence and also built new land. However, the river was channelized and leveed in the early 1900’s. Because of this anthropogenic effect, areas that did not receive sediment-laden floodwaters continually lost elevation. Further compounding this effect, the suspended sediment load in the Mississippi River has decreased more than 50 percent since the 1950’s, largely as a result of dam and reservoir construction and soil conservation practices in the drainage basin (Turner and Cahoon, 1988).

Saltwater intrusion, as a result of river channelization and canal dredging, is a major cause of coastal habitat deterioration (including submerged vegetation communities) (Boesch et al., 1994). Productivity and species diversity associated with SAV habitat in the coastal marshes of Louisiana are greatly reduced by saltwater intrusion (Stutzenbaker and Weller, 1989; Lirman et al., 2008). Due to increased salinities

farther up the estuaries, some salt tolerant species of submerged vegetation (including seagrasses) are able to populate areas farther inland and outcompete the dominant SAV species (Longley, 1994). Large shifts in salinities can decrease both seagrass and SAV populations, which decreases their ecological function for juvenile fishes and invertebrates. An example of a salinity shift that occurs in Louisiana is the opening of the Bonnet Carré Spillway to divert the Mississippi River flood waters into Lake Pontchartrain during high-water stages. This freshwater eventually flows into Mississippi and Chandeleur Sounds, lowering salinities there. In the past, spillway openings have been associated with a noticeable decrease in seagrass vegetation acreage (Eleuterius, 1987). Conversely, the Caernarvon Freshwater Diversion into the Breton Sound Basin, east of the River, provides more regular flooding events, which have reduced average salinities there. Reduced salinities there have triggered a large increase in acreage of submerged aquatic vegetation like *R. maritima* (Cho et al., 2009).

When the Mississippi River is in flood condition, floodways may be opened to alleviate the threat of levee damage (e.g. Bonne Carré Spillway). The floodways of the Mississippi River direct water to estuarine areas where flood waters may suddenly reduce salinities for a couple of weeks to several months. This lower salinity can damage or kill high-salinity seagrass beds if low salinities are sustained for longer periods than the seagrass species can tolerate (Eleuterius, 1987). If this continues to happen, over time seagrass beds could become stressed and more vulnerable to other impacts.

Submerged vegetation communities can be scarred by boat anchors, keels, and propellers, and by activities such as trampling, trawling, and seismic surveys (Sargent et al., 1995; Dunton et al., 1998). Loggerhead turtle, other large animals, and storm events can scar vegetated bottoms. A few State and local governments (Seagrass Outreach Partnership) have instituted management programs that have resulted in reduced scarring, which could decrease bed patchiness.

Currently, there is a period of significant increased tropical cyclone activity in the Gulf of Mexico. These storms can remove or bury submerged beds and the barriers that protect them from storm surges. This could weaken the existing populations of local submerged vegetation. Seagrass beds have been repeatedly damaged by the natural processes of transgression from hurricane overwash of barrier islands. Storm-generated waves wash sand from the seaward side of the islands over the narrow islands and cut new passes through the islands. The overwashed sand buries seagrass beds on the back side of the islands. Cuts formed in the islands erode channels that remove seagrass in its path. Over time, seagrass recolonizes the new sand flats on the shoreward side, and the natural processes of sand movement rebuild the islands. Hurricane impacts can produce changes in seagrass community quality and composition. These increased tropical cyclone events coincide with the current period of global climate changes. Global climate change can increase surface temperature, increase sea levels, and increase storm events (Orth et al., 2006). Whether it is from anthropogenic activities or a cycle, it has effects on seagrass beds by adding stress to this sensitive and already stressed ecosystem (Orth et al., 2006).

Summary and Conclusion

In general, the CPA proposed action would cause a minor incremental contribution to impacts on submerged vegetation from dredging, pipeline installations, possibly oil spills, and boat scarring. Dredging generates the greatest overall risk to submerged vegetation, while naturally occurring hurricanes cause direct damage to beds. The implementation of proposed lease stipulations and mitigation policies that are currently in place, the small probability of an oil spill, and that flow regimes are not expected to change further reduce the incremental contribution of stress from the CPA proposed action on submerged vegetation.

4.1.1.6. Live Bottoms

4.1.1.6.1. Live Bottoms (Pinnacle Trend)

A detailed description of live bottoms (Pinnacle Trend) can be found in Chapter 3.2.2.1.1 of the Multisale EIS. Updated information following Hurricanes Katrina and Rita (2005) is presented in Chapter 4.1.4.1.1 of the 2009-2012 Supplemental EIS. The BOEMRE recommends oil and gas operators to avoid contact with Pinnacle Trend features and provides a 100-ft (30-m) buffer zone as described in NTL 2009-G-39, "Biologically-Sensitive Underwater Features and Areas" (USDOI, MMS, 2009b). The following information is a summary of the resource description for the Pinnacle Trend incorporated from

the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

4.1.1.6.1.1. Description of the Affected Environment

The northeastern portion of the CPA exhibits a region of high topographic relief known as the "Pinnacle Trend" at the outer edge of the Mississippi-Alabama shelf between the Mississippi River and De Soto Canyon. The Pinnacle Trend spreads over a 103 x 26 km area (64 x 16 mi) in water depths of 60-200 m (200-650 ft) (**Figure 4-4**). It includes pinnacles, flat-top reefs, patch reefs, reef-like mounds, and isobath parallel ridges (Sager et al., 1992; Brooks and Giammona, 1990; CSA, 1992a).

The shape and configuration of these structures is similar to tropical coral reef formations. Early investigators of this area in 1957 hypothesized that they are "drowned calcareous reefs" (Ludwick and Walton, 1957). Drowned reefs are reefs that were shallow carbonate reefs long ago but their vertical growth has been outpaced by sea-level rise and seafloor subsidence, resulting in a skeletal reef structure in water too deep and dark to support a living coral reef (Schlager, 1981). More recent studies using dredges, grab samples, and imaging have confirmed this evaluation. Some of these formations are tall and steep-sided in profile. The taller mounds tend to have more complex shapes with pits and overhangs, in addition to flat tops and vertical sides (CSA and GERG, 2001).

Pinnacle Trend features consist of both high-relief outcroppings at the edge of the Mississippi-Alabama shelf and low-relief hard bottoms on the inner and middle shelf. High-relief features consist of pinnacles, flat-top reefs, reef-like mounds, patch reefs, and isobath-parallel ridges. The high-relief features are complex in shape and structure and provide varied zones of microhabitat for attached organisms. Low-relief features include fields of small seafloor mounds that rise only a meter or two from the seafloor but provide hard surfaces for encrusting and attached epifauna. Both high- and low-relief features are relict features that developed prior to the most recent sea-level rise and do not support active reef-building activity (Thompson et al., 1999). Fields of shallow depressions about 1 to 5-6 m across (3-20 ft) also add complexity to the overall character of the Pinnacle Trend area.

The eastern part of the pinnacles area is covered with a thin, well-sorted layer of fine- to medium-grained quartzose sand from eastern continental rivers. The western portion is covered with fine silts, sands, and clays deposited by the Mississippi River (CSA, 1992a). The linear orientation and distribution of pinnacles correspond with depth contours and may represent a historic shoreline. The rocky pinnacles provide a surprising amount of surface area for the growth of sessile invertebrates and attract large numbers of fish. Additional areas of hard bottom are located nearby on the continental shelf, outside the Pinnacle Trend. These low-relief, hard bottom areas are discussed in **Chapter 4.1.1.6.2.1**.

The BOEMRE has sponsored numerous studies providing information about these features (Brooks, 1991; CSA, 1992a; Thompson et al., 1999; CSA and GERG, 2001). A recent bathymetric survey by USGS has provided accurate, up-to-date imaging of the seafloor of the region (Gardner et al., 2002a). The Pinnacle Trend covers 74 lease blocks in the CPA, which is where BOEMRE has applied the Live Bottom (Pinnacle Trend) Stipulation to protect the ecosystem (**Figure 4-4**). This area includes portions of the continental shelf, shelf break, and upper continental slope. The outer limit of the continental shelf is delineated by the 75-m (246-ft) depth contour. Figure 3-4 of the Multisale EIS provides a perspective view of the central sector of the Mississippi-Alabama continental shelf. The BOEMRE recommends the application of the Live Bottom (Pinnacle Trend) Stipulation for a proposed action within 1 of the 74 OCS lease blocks that has Pinnacle Trend features.

Pinnacles

Tall spire-like mounds are the historical "pinnacles" for which the region is named. **Figure 4-5** shows a drawing of a pinnacle in the foreground. The pinnacles rise up to 20 m (66 ft) in height and can be over 500 m (1,640 ft) in diameter (Thompson et al., 1999; Brooks, 1991). They are scattered along the 74- to 82-m (243- to 269-ft) depth range and also extend laterally for over 28 km (17 mi) at the 105- to 120-m (345- to 394-ft) depth band (Thompson et al., 1999; Schroeder, 2000). The sides are steep and provide surface area for biological growth (CSA, 1992a). Pinnacles may have formed from coral-algal assemblages during a rapid sea-level rise (Brooks, 1991).

Patch Reefs

Patch reefs are small mushroom-shaped features about 2-12 m (6-39 ft) in diameter and 3-4 m (10-13 ft) in height that occur in many areas (Figure 3-4 of the Multisale EIS). They are particularly abundant in fields of as many as 35-70 features per hectare (2.47 ac) along the 74- to 82-m (243- to 269-ft) depth contour in two separate fields on the western portion of the shelf (Brooks, 1991; Schroeder, 2000).

Flat-Top Reefs

Flat-top reefs (Figure 3-4 of the Multisale EIS) are large reef-like structures that occur along the same depth contour as patch reefs (74-82 m; 243-269 ft) and follow the shelf edge for a distance of over 70 km (43 mi) (Brooks, 1991). They are located in the west-central region of the Mississippi-Alabama shelf (Schroeder, 2000). The reefs range from 75 to 700 m (245 to 2,300 ft) in diameter and from 7 to 14 m (23 to 46 ft) in height. The structures have steep sides like the pinnacles, but are flat on top. The flat tops of these features are all at essentially the same depth of 66 m (216 ft), which was probably at the sea surface during their period of formation (Sager et al., 1992).

Reef-Like Mounds

Pinnacles and flat-top reefs fall into the category of reef-like mounds; however, these formations are also present elsewhere (Thompson et al., 1999). Figure 3-4 of the Multisale EIS shows examples of these features. Several clusters are found shoreward in 60-70 m (197-230 ft) of water. In the western part of the pinnacle area, two clusters of reef-like mounds are found at the 87- to 94-m (285- to 308-ft) depth range (Figure 3-4 of the Multisale EIS) (Brooks, 1991). The mounds are 4 m (13 ft) high and 10-70 m (33-230 ft) wide. These features are also present along the western rim of the De Soto Canyon at depths of 70-80 m (230-262 ft) (Schroeder, 2000).

Ridges and Scarps

Ridges (**Figure 4-6**) are the largest features in the area and are found between the 68- and 76-m (223- to 249-ft) depth range (Schroeder, 2000). Linear ridges paralleling the isobaths are reported in various depths (Brooks, 1991; Thompson et al., 1999). These ridges are typically about 20 m (66 ft) wide (up to 250 m [820 ft]) and over 1 km (0.6 mi) long. Some ridges are 15 km (9 mi) long (Schroeder, 2000). Most of the ridges are low relief, around 1 m (3 ft) in height. Brooks (1991) found a ridge with scarps up to 8 m (26 ft) high in depths around 60 m (197 ft). They often occur in groups of 6-8 ridges together. They appear to be calcareous biogenic features formed during periods of slow sea-level rise during the last deglaciation (Sager et al., 1992), possibly from lithified coastal dunes (Thompson et al., 1999).

Shallow Depressions

Shallow depressions are another type of low-relief feature common in the pinnacle area, particularly to the west of the large pinnacle features (Figure 3-4 of the Multisale EIS). These occur in large fields that do not follow depth contours. The formations are found in large clusters (up to 80 per km^2) (Sager et al., 1992). They are usually irregularly shaped with bumpy rims, 5-10 m (16-33 ft) across, and probably less than a meter in depth. It is thought that they are formed by the collapse of sediments following gas expulsion (Brooks, 1991).

Nepheloid Layer

A persistent nepheloid layer characterized by high turbidity was identified as a controlling factor for hard-bottom communities in the northwestern Gulf of Mexico (Rezak et al., 1985). The nepheloid layer is a heavy layer of turbid water laden with sediment that is carried along by water currents above the seafloor. This layer reduces the light reaching the reef, resulting in decreased epibiota and reef fish species richness and abundance below 80 m (262 ft) (Dennis and Bright, 1988; Rezak et al., 1990). Previous studies have suggested that the Mississippi River plume influences the distribution and

abundance of sessile invertebrates within 70 km (43 mi) of the river delta and may produce a gradient of sedimentation and water-column turbidity throughout the Pinnacle Trend (Gittings et al., 1992a; CSA and GERG, 2001). In the northeastern Gulf, nepheloid layers are infrequent; although in conjunction with episodic Mississippi freshwater plumes and upwelling, they result in increased light attenuation (CSA and GERG, 2001).

Ecology of the Pinnacle Trend Area

The pinnacles provide a significant amount of hard substrate for colonization by suspension-feeding invertebrates and support relatively rich live-bottom and fish communities. Assemblages of coralline algae, sponges, octocorals, crinoids, bryozoans, and fishes are present at the tops of the shallowest features in water depths of less than 70 m (230 ft) (CSA, 1992a). On the deeper features, as well as along the sides of these shallower pinnacles, ahermatypic corals may be locally abundant, along with octocorals, crinoids, and basket stars. The diversity and abundance of the associated species appear to be related to the size and complexity of the features, with the low-relief rock outcrops (<1 m [3 ft] height) typically having low faunal densities, and higher relief features having the more diverse faunal communities (Gittings et al., 1992a; Thompson et al., 1999).

Environmental Influences on the Pinnacle Trend Area

Substrate characteristics and turbidity seem to be the major factors determining the composition of communities at different locations and depth levels in the Pinnacle Trend. The biological communities on the Pinnacle Trend become more diverse toward the east and with greater distance from the Mississippi River (Gittings et al., 1992a). This is a matter of both substrate and turbidity. The Mississippi River brings a large load of fine silty sediment to the Gulf of Mexico. Although the majority of this turbidity is swept to the west by currents, it does affect the communities to the east. Sometimes the pattern is reversed with the majority swept to the east. Previous studies have suggested that the Mississippi River plume influences the distribution and abundance of sessile invertebrates within 70 km (43 mi) of the river delta and may produce a gradient of sedimentation and water-column turbidity throughout the Pinnacle Trend (Gittings et al., 1992a; CSA and GERG, 2001).

In addition, a nepheloid layer (heavy bottom turbidity layer), common in the western Gulf of Mexico, sometimes affects the Pinnacle Trend (Weaver et al., 2002). Resuspension of sediments is a major contributor to turbidity in the Pinnacle Trend. This is more severe in the western part of the Pinnacle Trend area because currents and wave action resuspend the silty sediments deposited by the Mississippi River.

Because of the depth of the bottom (60-120 m; 200-400 ft) in the Pinnacle Trend area, waves seldom have a direct influence. During severe storms, such as hurricanes, large waves may reach deep enough to stir bottom sediments. These forces are not expected to be strong enough to cause direct physical damage to organisms living on the reefs. Rather, currents are created by the wave action that can resuspend sediments to produce added turbidity and sedimentation (Brooks, 1991; CSA, 1992a). The animals in this region are well-adapted to the effects common to this frequently turbid environment. The end result of these factors is that benthic communities closer to the Mississippi River are less diverse (CSA, 1992a).

Diversity and density of epibenthic organisms varies considerably between features in the Pinnacle Trend area. The general trend is less turbidity and greater biological development toward the east. In addition, the sediment is less silty to the east. This results in an increase of diversity and density of organisms to the east. Other factors, such as areas with more exposed hard bottom, vertical relief, rugosity, and complexity of the substrate contribute to higher biological diversity and density.

The association of multiple features in proximity to one another makes an area more biologically diverse and promotes higher densities of organisms than an area with fewer, more scattered features (Gittings et al., 1992a). The Pinnacle Trend is a system of exposed hard substrates. Low-relief mounds, patch reefs, flat-top reefs, tall pinnacles, and ridge formations are often found in groups or clusters, creating a cumulative environment (Brooks, 1991). The reefs are richer because they are in proximity to each other. Even solitary, simple, low-relief mounds support low-diversity assemblages, which combine with major features to form a large reef tract. The Pinnacle Trend forms a major ecosystem with an influence that pervades the wider regional ecosystem.

Pinnacle Zonation

The characteristics of the substrate have a high degree of control over the composition of the biological communities that live on it. The features of the Pinnacle Trend are composed of carbonate reef material (Ludwick and Walton, 1957) and vary in shape, size, and vertical relief. The more complex the topographic shape of the substrate, the greater the variety of habitats for organisms and thus more high-density, biologically diverse communities. Shallow depressions and low mounds harbor some organisms, but the potential is limited. A pinnacle 20 m (66 ft) tall with slopes, cliffs, crevices, and overhangs may host the maximum number of species and a high density of animals (Gittings et al., 1992a). The bottom of a tall pinnacle will have very low diversity with mostly upright species present, such as comatulid crinoids; the ahermatypic hard coral, *Rhizopsammia manuelensis*; the black corals, *Antipathes* spp. and *Cirrhipathes* sp.; and the gorgonian, *Ellisella* sp. (Gittings et al., 1992a). The roughtongue bass, *Pronotogrammus martinicensis*, is the dominant fish at the base of pinnacles. Other common fish near the bottom are the red barbier, *Hemanthias vivanus*; cubbyu, *Pareques umbrosus*; bigeye soldierfish, *Ostichthys trachpoma*; and wrasse bass, *Liopropoma eukrines* (Weaver et al., 2002).

Features tall enough to rise above the common effects of turbidity have higher community diversity and density. At least 34 different epibenthic species were found during one study of the shelf-edge features (CSA, 1992a). Vertical walls were densely populated by *R. manuelensis*, with frequent occurrence of *Antipathes* spp., *Cirrhipathes luetkeni*, and *Ellisella* sp. Some other ahermatypic stony corals were also seen, including *Madrepora carolina*, *Madracis myriaster*, *Oculina diffusa*, and a solitary cup coral, possibly *Balanophyllia floridana*. Comatulid crinoids were also observed. This zone was dominated by the roughtongue bass and red barbier (Weaver et al., 2002).

The crests of the pinnacles are perhaps slightly more diverse than the walls. The same dominant species were seen as on the walls, with the common addition of the gorgonian coral, *Bebryce* sp. (Gittings et al., 1992a). Species richness is high at the crest of pinnacles, and *R. manuelensis* is very common. Coralline algae occur on hard substrates above about 78-m (256-ft) depth (Gittings et al., 1992a). The crests and walls of pinnacles are dominated by low-growing, ahermatypic hard corals. Fish communities on pinnacle crests are dominated by the red barbier; roughtongue bass; Gobiidae; greenband wrasse, *Halichoeres bathyphilus*; and yellowtail reeffish, *Chromis enchrysura* (Weaver et al., 2002).

Horizontal surfaces provide surface area for considerably higher biological cover than vertical surfaces. This is likely because a greater number of individuals are able to settle and colonize a horizontal surface (Gittings et al., 1992a). Dominant species are similar to those on the walls of the pinnacles. However, some species not present on vertical surfaces are found on horizontal surfaces, including several sponges (*Geodia neptuni*, *Cinachyrella* sp., and unidentified orange sponges) and a gorgonian coral, possibly *Nicella* sp. (Gittings et al., 1992a). The tops of reefs with extensive flat summits are dominated by the taller gorgonian corals, as well as by sponges and crinoids. It is likely that sedimentation limits the colonization of low-growing species on these horizontal surfaces, such as many of the ahermatypic hard corals (Gittings et al., 1992a). Dominant fish species on the flat tops include the red barbier, roughtongue bass, gobies, yellowtail reeffish, and greenband wrasse (Weaver et al., 2002).

Pinnacle Trend Field Studies

Within the Pinnacle Trend area, the feature known as "36 Fathom Ridge" was studied in some detail. The 36 Fathom Ridge is part of the Alabama Alps formation. Refer to **Figure 4-7** for the location and topography of this feature. It is 250 m (820 ft) wide and 1 km (0.6 mi) long and oriented in a north-south direction (Brooks and Giammona, 1990). The feature has a maximum relief of 16 m (52 ft), with the base 88 m (289 ft) below the sea surface and the crest 72 m (236 ft) below the surface (Weaver et al., 2002). The top of this feature is an irregular, fairly flat surface colonized by octocorals (*Bebryce cinerea*, *Bebryce grandis*, *Nicella* spp., *Ellisella* sp., *Cirrhipathes* sp., *Antipathes atlantica*, and *Ctenocella* spp.), crinoids (*Stichopathes lutkeni* and *Antipathes* sp.), gorgonians (*Astrocyclus caecilian*), ahermatypic coral (*Rhizopsammia manuelensis*), coralline algae, sea fans, ascidians, urchins, and sponges (*G. neptuni*) (CSA, 1992a; Thompson et al., 1999; Hardin et al., 2001). Flat sections of this feature are also covered by a silt to sand sediment veneer. The steep sides of the feature are dominated by a dense cover of *Rhizopsammia manuelensis*, a solitary coral. Comatulid crinoids, soft corals (*Antipathes* spp., *Cirrhipathes luetkeni*), some nonreef-building hard corals (*Madracis myriaster*, *Oculina diffusa*), coralline algae, and sponges are also present (CSA, 1992a; Thompson et al., 1999; Harden et al., 2001).

The walls of the feature were interspersed by some flat areas supporting even greater live cover including sponges (*Geodia neptuni, Cinachtrella* sp.), in addition to the vertical wall organism assemblage. The base of the feature supported low live cover that included the ahermatypic black coral *Rhizopsammia manuelensis*, several species of the Antipatharian, *Antipathes* sp., and several species of comatulid crinoids (CSA, 1992a; Thompson et al., 1999).

Other ridges smaller than 36 Fathom Ridge had very similar composition and amount of live cover to the 36 Fathom Ridge (CSA, 1992a). One of the mound-like features described by CSA (1992a) was located in water 94 m (308 ft) deep, was 11 m (36 ft) tall, 200 m (656 ft) wide, and 250 m (820 ft) long. The most common species colonizing the lower parts of the mound was *R. manuelensis*. There were also soft corals (*Ellisella* sp., *Cirrhipathes* sp.), comatulid crinoids, and antipatharians. Higher up on the mound, there was a greater density of *R. manuelensis*, together with the nonreef-building corals (*Madrepora carolensis*, *M. myriaster*, and *Oculina* sp.), antipatharians (*Antipathes* sp.), comatulid crinoids, and soft corals (*Nicella* sp.).

Roughtongue Reef (**Figure 4-8**) is an elliptical feature with a 400-m (1,300-ft) diameter base, a flat top covered with sediment, and steep sides (Weaver et al., 2002). A smaller reef is attached to the south. Roughtongue Reef has a maximum relief of 14 m (46 ft), with the base at 78 m (256 ft) below the sea surface and the crest at 64 m (210 ft) below the surface (Weaver et al., 2002). Bioturbation from infaunal benthic organisms has been reported in the sediment on the top of the reef (Hardin et al., 2001). Organisms living on top of the reef are diverse and include octocorals (*Bebryce cinera*, *Bebryce grandis*, *Nicella* spp., *Thesea* sp., Stenogorgiinae, and *Ctenocella* spp); sponges (*Ulosa* sp., *Dysidea* sp., and *Ircinia campana*); crinoids; ectoprocts (*Cellaria* sp. and *Idmidronea* sp.); and an antipatharian spiral whip (*Stichopathes lutkeni*) (Hardin et al., 2001). The sides of Roughtongue Reef have a lower density of organisms and are dominated by *R. manuelensis*. The base of the feature also had *R. manuelensis*, along with octocoral fans and coral (*Madracis* sp., *Oculina* sp., and *Ctenocella* spp.) (Hardin et al., 2001). The roughtongue bass is also abundant here (Weaver et al., 2002).

4.1.1.6.1.2. Impacts of Routine Events

Background/Introduction

A detailed description of the possible impacts from routine activities associated with the CPA proposed action on Pinnacle Trend communities is presented in Chapter 4.2.2.1.4.1.1 of the Multisale EIS and in Chapter 4.1.4.1.2 of the 2009-2012 Supplemental EIS. The routine activities associated with the proposed action that would impact Pinnacle Trend communities in the CPA include anchoring, infrastructure and pipeline emplacement, infrastructure removal, drilling discharges, and produced-water discharges. The following is a summary of the information presented in the Multisale EIS and the2009-2012 Supplemental EIS, which incorporates new information found since publication of the Multisale EIS and the 2009-2012 Supplemental EIS and in consideration of the DWH event.

Seventy-four blocks are within the region defined as the Pinnacle Trend, which contains live bottoms that may be sensitive to oil and gas activities. These blocks are located in the northeastern portion of the CPA and are located in water depths between 60 and 120 m (197 and 394 ft) in the Main Pass, Viosca Knoll, and Destin Dome lease areas. Relevant leases in past sales have contained a Live Bottom (Pinnacle Trend) Stipulation to protect such areas. The proposed Live Bottom (Pinnacle Trend) Stipulation is presented in **Chapter 2.4.1.3.2** as a potential mitigating measure for leases resulting from the proposed action. The BOEMRE recommends the implementation of the Live Bottom (Pinnacle Trend) Stipulation for a proposed action within 1 of the 74 OCS lease blocks that has Pinnacle Trend features. The stipulation is designed to prevent drilling activities and anchor emplacement (the major potential impacting factors on these live bottoms resulting from offshore oil and gas activities) from damaging the pinnacle features. Under the stipulation, both exploration and development plans will be reviewed on a case-by-case basis to determine whether a proposed operation could impact a pinnacle feature. If it is determined from site-specific information derived from BOEMRE studies, published information from other research programs, geohazards survey information, or another source that the operation would impact a pinnacle feature, the operator may be required to relocate the proposed operation.

Although the Live Bottom (Pinnacle Trend) Stipulation is regarded as a highly effective protection measure, infrequent impacts are possible. Impacts may be caused by operator positioning errors or when

studies and/geohazards information are inaccurate or fail to note the presence of pinnacle features. One such incident has been documented and is discussed in further detail below. While investigating sites of previous oil and gas drilling activities, Shinn et al. (1993) documented that a lease operator had located an exploratory well adjacent to a medium-relief pinnacle feature; the reason for this occurrence is still undetermined. In spite of this documented instance, the stipulation is still considered effective since it allows BOEMRE flexibility to request any surveys or monitoring information necessary to ensure protection of these sensitive areas. The impact analysis presented below is for routine activities associated with the CPA proposed action and includes the proposed Live Bottom (Pinnacle Trend) Stipulation.

A number of OCS-related factors may cause adverse impacts on the live-bottom communities and features. Damage caused by anchoring, infrastructure and pipeline emplacement, infrastructure removal, blowouts, drilling discharges, produced-water discharges, and oil spills can cause the immediate mortality of live-bottom organisms or the alteration of sediments to the point that recolonization of the affected areas may be delayed or impossible. Accidental impacts from oil spills and blowouts are discussed in **Chapter 4.1.1.6.1.3**.

Construction Impacts on Pinnacle Trend Features

Anchoring may damage lush biological communities or the structure of the live-bottom features themselves, which attract fish and other mobile marine organisms. Anchor damage from support boats and ships, floating drilling units, and pipeline-laying vessels greatly disturb areas of the seafloor and are the greatest threats to live-bottom areas at these depths. The size of the affected area would depend on water depth, anchor and chain sizes, chain length, method of placement, wind, and current. Anchor damage may result in the crushing and breaking of hard bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary species (cup corals, octocorals, and hydrocorals) may recolonize areas more rapidly than slow-growing colonial forms that disperse larvae great distances (Lissner et al., 1991). Pinnacle features would be protected from possible anchor damage through NTL 2009-G39. The proposed Live Bottom (Pinnacle Trend) Stipulation states that no bottom-disturbing activities are permitted within 30 m (100 ft) of the hard-bottom feature. Therefore, anchoring damage would only occur if the proposed stipulation is not followed.

The emplacement of infrastructure, including drilling rigs and platforms, on the seafloor would crush the organisms directly beneath the legs or mat used to support the structure. Pipeline emplacement directly affects the benthic communities by crushing it under the pipeline or trenching and burial of the pipeline (in less than 60 m [200 ft] water depth) and the resultant resuspension of sediments. These resuspended sediments may obstruct filter-feeding mechanisms and gills of fishes and sedentary invertebrates. The areas affected by the placement of the platforms and rigs are predominantly soft-bottom regions where the infaunal and epifaunal communities are not unique as the hard-bottom communities.

Infrastructure and pipeline emplacement could result in suspended sediment plumes and sediment deposition on the seafloor. Considering the relatively elevated amounts of drilling muds and cuttings discharged per well (approximately 2,000 metric tons [2,205 tons] for exploratory wells—900 metric tons [992 tons] of drilling fluid and 1,100 metric tons [1,213 tons] of cuttings—and slightly lower discharges for development wells) (Neff, 2005), potential impacts on biological resources of hard-bottom features should be expressly considered if drill sites occur in blocks containing such features. Potential impacts could be incurred through increased water-column turbidity, the smothering of sessile benthic invertebrates, and local accumulations of contaminants.

Differences in the dispersal patterns for well cuttings and drilling muds would result from differences in disposal methodology (surface disposal or bottom shunting). For example, well cuttings that are disposed of at the water's surface tend to disperse in the water column and are distributed widely over a

large area at low concentrations (CSA, 2004b; NRC, 1983). On the other hand, cuttings that are shunted to the seafloor are concentrated over a smaller area in piles instead of being physically dispersing over wide areas (Neff, 2005). The heaviest concentrations of well cuttings and drilling fluids, for both water-based and synthetic-based drilling muds, have been reported within 100 m (328 ft) of wells and are shown to decrease beyond that distance (CSA, 2004b; Kennicutt et al., 1996). They are usually distributed unevenly and in patches, often dependent on prevailing currents (CSA, 2004b). A gradient of deposition may reach up to 500 m (1,640 ft) from the well, depending on surrounding environmental conditions (Kennicutt et al., 1996).

Although the Live Bottom (Pinnacle Trend) Stipulation requires that no drilling be conducted within 30 m (98 ft) of pinnacles, some cuttings may reach the live-bottom features. Surface-released cuttings rarely accumulate thicknesses of about 1 m (3 ft) immediately adjacent to the well; thicknesses are usually not higher than a few tens of centimeters (about 1 ft) in the GOM. A gradient of cuttings that encompasses most of the cuttings settles within 100 m (328 ft) of the well site. Cuttings settle in a patchy distribution determined by water currents and limited to about 250 m (820 ft) from the well site (CSA, 2004b). Cuttings released at the surface, which are accumulating on the seafloor, should not completely cover organisms on pinnacles because the pinnacles have several meters relief above the seafloor and the organisms are those adapted to high levels of sedimentation.

In order to protect live-bottom features, the relocation of operations to avoid live-bottom areas, shunting drilling fluids and cuttings to avoid live-bottom areas, transportation of drilling fluids and cuttings to approved disposal sites, and/or site monitoring may be required. These measures would limit or prevent well drilling activities from occurring in sensitive live-bottom areas. If bottom shunting of cuttings is used to protect features, the live-bottom areas would experience little sedimentation. Also, the USEPA general NPDES permit sets special restrictions on discharge rates for muds and cuttings to protect biological features. Chapters 4.1.1.4.1 and 4.2.1.1.2.2 of the Multisale EIS detail the NPDES permit's general restrictions and the impacts of drilling muds and cuttings on offshore water quality and seafloor sediments. If cuttings and drilling fluids are transported to approved disposal sites, the live bottoms would be even further protected from sedimentation. Due to the Live Bottom (Pinnacle Trend) Stipulation and USEPA discharge regulations, turbidity and smothering impacts of sessile invertebrates on hard-bottom features caused by drilling muds and cuttings are anticipated to be minimized.

Drilling fluid adhering to cuttings forms plumes that are rapidly dispersed on the OCS. Approximately 90 percent of the material discharged (cuttings and drilling fluid) settle rapidly to the seafloor, while 10 percent forms a plume of fine mud that drifts in the water column (Neff, 2005). Although drilling mud plumes may be visible 1 km (0.6 mi) from the discharge, rapid dilution of drilling mud plumes was reported within 6 m (20 ft) from the release point (Shinn et al., 1980; Hudson et al., 1982). Drilling muds and cuttings may be diluted 100 times at a distance of 10 m (33 ft) from the discharge and 1,000 times at a distance of 100 m (328 ft) from the discharge (Neff, 2005). Dilution continues with distance from the discharge point, and at 96 m (315 ft) from the release point, a plume was measured only a few milligrams/liter above background suspended sediment concentrations (Shinn et al., 1980). Suspended sediment concentrations 6 m (20 ft) from the discharge are often less than those produced during storms or from boat wakes (Shinn et al., 1980). With consideration that drilling is not allowed within 30 m (100 ft) of pinnacles and considering that field measurements of suspended solids rapidly decline with distance from the source, turbidity impacts to live-bottom communities should be minimized.

It is not anticipated that muds drifting in the water column would exceed the natural turbidity levels in the Pinnacle Trend areas. The Pinnacle Trend community exists in a relatively turbid environment, starting just 65 km (40 mi) east of the mouth of the Mississippi River and trending to the northeast. The organisms in this area are tolerant of turbid environments (Rogers, 1990; Gittings et al., 1992a) and should not be impacted by the residual suspended sediment discharged during the drilling of a well. Many of the organisms that predominate in these communities also grow tall enough to withstand the sedimentation that results from their typical turbid environment or they have flexible structures that enable the passive removal of sediments (Gittings et al., 1992a). Their structure would also enable them to withstand the turbidity that may reach the live bottoms as a result of drilling of a well. Any mud that may reach these organisms can be removed by tentacle motion and mucus secretion (Shinn et al., 1980; Hudson and Robbin, 1980).

The resilience of some of the species found on pinnacle features was reported by Shinn et al. (1993). An exploratory well site erroneously located immediately adjacent to a 4-5 m (13-16 ft) high pinnacle feature, located at a water depth of 103 m (338 ft) was surveyed. Cuttings and drill debris were documented within 6,070 m^2 (1.5 ac) surrounding the drill site. In spite of being inundated by drill muds and cuttings 15 months prior to the investigation, the pinnacle feature was found to support a diverse community, which included gorgonians, sponges, nonreef-building stony corals, a species of horn coral, and abundant meter-long whip-like antipatharians characteristic of tropical hard-bottom communities in water depths of 30 m (100 ft) or greater. Shinn et al. (1993) concluded the following: "Gorgonians, antipatharians, crinoids, and non-reef-building corals attached to the pinnacle feature adjacent to the drill site as well as nearby rock bottom did not appear to be affected." Shinn et al. (1993) acknowledged that their evaluation of the drill site was constrained both by the lack of baseline data on the live-bottom community prior to inundation by drilling discharges and by the need for a study on long-term changes (e.g., 10 years).

Recruitment studies conducted by Continental Shelf Associates (CSA) and Texas A&M University, Geochemical and Environmental Research Group (GERG); Marine Resources Research Institute (MRRI); and others suggest that recovery of hard-bottom communities following physical damage will be slow (CSA and GERG, 2001; MRRI, 1984; Montagna and Holmberg, 2000). Hard-bottom communities studied during the Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring Program exhibit a dynamic sedimentary environment with relatively little net growth of the epibiota associated with the pinnacle features. Deeper habitats have slower rates of settlement, growth, and community development, and recruitment rates are reportedly slow in the pinnacle habitat (Montagna and Holmberg, 2000; CSA and GERG, 2001).

Epibiont recruitment showed relatively slow development of fouling community constituents on recruitment plates. Early colonizers are opportunistic epifauna, such as hydroids, bryozoans, barnacles, and bivalves that are tolerant of sediment loading (CSA and GERG, 2001; MRRI, 1984). Basically, only the earliest successional stages were observed after 1 year (MRRI, 1984) and after 27 months of exposure (CSA and GERG, 2001), and the epibiota typically associated with nearby hard-bottom features were rare on the plates (CSA and GERG, 2001). No sponges or corals had settled after 1 year (MRRI, 1984). Corals and sponges are known to display delayed recruitment and slow growth, and after 10 years, corals and anemones were sparse on artificial reef habitats and the community had still not reached "climax" state (MRRI, 1984).

It is not known whether the results of the recruitment studies would have differed if the substrate had consisted of exposed patches of natural hard bottom; however, because analysis of artificial reefs exposed for months to several years also indicates slow community development, it can be anticipated that hard-bottom communities take a long time to recruit and develop (MRRI, 1984). Although settling plates and artificial reefs may differ from natural reefs, they can help to indicate recruitment time of a defaunated area (MRRI, 1984). This recruitment data indicates that, even though one survey showed thriving hard-bottom communities adjacent to a well 15 months after the well was drilled, drilling discharges are still considered to have a deleterious impact on the live-bottom communities, and the Live Bottom (Pinnacle Trend) Stipulation would continue to be applied to minimize the possibility of similar occurrences.

Long-Term and Operational Impacts on Pinnacle Trend Features

Drilling operations may impact live-bottom communities. Drilling operations in Puerto Rico have led to reduced coral cover out to 65 m (213 ft) from the well, probably as a result of cutting deposition (Hudson et al., 1982). Corals beyond this distance did not show reduced surface cover (Hudson et al., 1982). Live bottoms of pinnacle features may experience some deposition of cuttings, especially if a well is within a few hundred meters of a live bottom. Impacts as a result of cuttings disposal may reach 100-200 m (328-656 ft) from a well (Montagna and Harper, 1996; Kennicutt et al., 1996). The proposed Live Bottom (Pinnacle Trend) Stipulation requires all bottom-disturbing activity to be at least 30 m (100 ft) from the pinnacles. This distance is within the deposition zone measured as a result of drilling operations in the Gulf of Mexico (Montagna and Harper, 1996; Kennicutt at al., 1996). If BOEMRE determines that the proposed activity may adversely impact the feature, then the lessee may be required to undertake protective measures (e.g., relocation of operations) or to monitor the potential impact. Further protection may be implemented if the cuttings and drilling fluids are transported to an approved disposal

site. The implementation of the Live Bottom (Pinnacle Trend) Stipulation is anticipated to reduce exposure pathways of drilling activities to benthic organisms on live bottoms, eliminating long-term operational impacts such as exposure to turbidity and sedimentation or associated contaminants.

Impacts resulting from exposure to contaminants may occur to live-bottom organisms within 100-200 m (328-656 ft) of the well as a result of offshore oil and gas production (Montagna and Harper, 1996; Kennicutt et al., 1996; Hart et al., 1989; Kennicutt, 1995; CSA, 2004b). Sand content, metals, barium, inorganic carbon, and petroleum products have all been reported to be elevated near platforms (Kennicutt, 1995). Distribution of discharges tends to be patchy, have sharp gradients, and be directional (Kennicutt, 1995). The greatest impacts occur in low-energy environments where depositions may accumulate and not be redistributed (Neff, 2005; Kennicutt et al., 1996).

Elevated levels of barium, silver, cadmium, mercury, lead, and zinc were found out to 200 m (656 ft) from platforms and are likely a product of drilling muds and cuttings (Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). Metal concentrations in sediments near gas platforms (approximately out to 100 m [328 ft]) have been reported above those that may cause deleterious biological effects. The impacts are believed to be a result of metal toxicity originating from drill cuttings during the installation of the well, which remain in the sediment (Montagna and Harper, 1996; Carr et al., 1996). Hydrocarbon enrichment has been reported within 25 m (82 ft) and out to 200 m (656 ft) of petroleum platforms, and the concentrations decreased with distance from the platforms (Hart et al., 1989; Chapman et al., 1991; Kennicutt, 1995; Kennicutt et al., 1996). The concentrations of PAH's in the sediment surrounding platforms, however, were below the biological thresholds for marine organisms and appeared to have little effect on benthic organisms (Hart et al., 1989; McDonald et al., 1996; Kennicutt et al., 1996). If any of the drill cuttings reach live-bottom features, impacts from metal or hydrocarbon exposure may occur. Although the literature does not report the impacts to gorgonians or soft corals as a result of exposure to contaminants in cuttings, infauna has shown effects including reduced fecundity, altered populations, and acute toxicity (Montagna and Harper, 1996; Carr et al., 1996; Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). Impacts to benthos would be reduced with distance from the discharge.

Produced waters are discharged at the water surface throughout the lifetime of the production platform and may contain hydrocarbons, trace metals, elemental sulfur, and radionuclides (Kendall and Rainey, 1991). Heavy metals enriched in the produced waters include cadmium, lead, iron, and barium (Trefry et al., 1995). Produced waters may impact both organisms attached to the production platform and benthic organisms beneath the platform. A detailed description of the impacts of produced waters on water quality and seafloor sediments is presented in Chapter 4.2.1.1.2 of the Multisale EIS.

Information is contradictory on the distance from a platform that produced waters can affect benthic communities. Impacts have been reported from 100 m (328 ft) of the source to 1 km (0.6 mi) from the source (Peterson et al., 1996; Armstrong et al., 1977; Osenberg et al., 1992). The produced waters, however, are rapidly diluted and impacts are generally only observed within the proximity of the discharge point (Gittings et al., 1992b). Literature indicates that acute toxicity that may result from produced waters occurs "within the immediate mixing zone around a production platform" (Holdway, 2002). Past evaluation of the bioaccumulation of offshore produced-water discharges conducted by the Offshore Operators Committee (Ray, 1998) assessed that metals discharged in produced water would, at worst, affect living organisms found in the immediate vicinity of the discharge, particularly those attached to the submerged portion of platforms. Possibly toxic concentrations of produced water were reported 20 m (66 ft) from the discharge in both the sediment and the water column where elevated levels of hydrocarbons, lead, and barium occurred; no impacts to marine organisms or sediment contamination were reported beyond 100 m (328 ft) of the discharge (Neff and Sauer, 1991; Trefry et al., 1995). Chronic exposure to produced waters may result in altered benthic communities, favoring opportunistic species, altered species behavior, reduced growth, and decreased fecundity (Holdway, 2002).

Naturally occurring radioactive material in produced water was not found to bioaccumulate in marine animals (2 species of mollusks and 5 species of fish) (Ray, 1998). Because high-molecular PAH's are usually in such dilute concentrations in produced water, they pose little threat to marine organisms and their constituents, and they were not anticipated to biomagnify in marine food webs. Monocyclic hydrocarbons and other miscellaneous organic chemicals are known to be moderately toxic, but they do not bioaccumulate to high concentrations in marine organisms and are not known to pose a risk to their consumers (Ray, 1998).

Produced waters may have some impact on live-bottom features, but the Live Bottom (Pinnacle Trend) Stipulation should help to reduce these impacts. The greatest impacts are reported adjacent to the discharge and out to 20 m (66 ft) from the discharge, but they are substantially reduced less than 100 m (328 ft) from the discharge. Because no bottom-disturbing activities are permitted within 30 m (100 ft) of the pinnacles, produced waters would not be discharged within 30 m (100 ft) of the pinnacles. Since produced waters are rapidly dispersed, the distance between the pinnacles and the discharge would allow for dispersion of the produced waters, reducing the concentration of discharged material to which the pinnacles may be exposed. The USEPA general NPDES permit restrictions on the discharge of produced water would also help to limit the impacts on biological resources of live bottoms.

Structure-Removal Impacts on Pinnacle Trend Features

The impacts of structure removal on live-bottom benthic communities can include turbidity, sediment deposition, explosive shock-wave impacts, and scouring from trawling to retrieve debris. Both explosive and nonexplosive removal operations would disturb the seafloor by generating considerable turbidity. Suspended sediment may evoke physiological impacts in benthic organisms including “changes in respiration rate, abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus” (Anchor Environmental CA, L.P., 2003). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Sediment deposition that occurs in ahermatypic (nonreef-building) coral communities may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced coverage, changes in species diversity and dominance patterns, alterations in growth rates and forms, decreased calcification, increased production of mucus, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Octocorals and gorgonians are more tolerant of sediment deposition than scleractinian corals, as they grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a). Gorgonians, corals, and sponges on low-relief features have also been reported to protrude above accumulated sediment layers, and it is hypothesized that these organisms can resist burial by growing faster than the sediment accumulates over the hard substrate upon which they settle (Lissner et al., 1991).

The shock waves produced by explosive structure removals may also harm benthic biota. However, corals and other sessile invertebrates have a high resistance to shock. O’Keeffe and Young (1984) described the impacts of underwater explosions on various forms of sea life using, for the most part, open-water explosions much larger than those used in typical structure-removal operations. They found that sessile benthic organisms, such as barnacles and oysters, and many motile forms of life, such as shrimp and crabs, that do not possess swim bladders were remarkably resistant to shock waves generated by underwater explosions. Oysters located 8 m (26 ft) away from the detonation of 135-kilogram (kg) (298-pound [lb]) charges in open water incurred a 5 percent mortality rate. Crabs distanced 8 m (26 ft) away from the explosion of 14-kg (31-lb) charges in open water had a 90 percent mortality rate. Few crabs died when the charges were detonated 46 m (151 ft) away. O’Keeffe and Young (1984) also noted “. . . no damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods.”

Benthic organisms appear to be further protected from the impacts of subbottom explosive detonations by rapid attenuations of the underwater shock wave traversing the seabed away from the structure being removed. The shock wave is significantly attenuated when explosives are buried as opposed to detonation in the water column (Baxter et al., 1982). Theoretical predictions suggest that the shock waves of explosives set 5 m (15 ft) below the seabed, as required by BOEMRE regulations, would further attenuate blast effects (Wright and Hopky, 1998).

Charges used in OCS structure removals are typically much smaller than some of those cited by O'Keeffe and Young. The *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (USDOI, MMS, 2005) predicts low impacts on the sensitive offshore habitats from platform removal precisely because of the effectiveness of the proposed Live Bottom (Pinnacle Trend) Stipulation in preventing platform emplacement in the most sensitive areas of the GOM. Impacts on the biotic communities, other than those on or directly associated with the platform, would be limited by the relatively small size of individual charges (normally 50 lb [27 kg] or less per well piling and per conductor jacket) and by the fact that charges are detonated 5 m (15 ft) below the mudline and at least 0.9 seconds apart (timing needed to prevent shock waves from becoming additive) (USDOI, MMS, 2005). Also, because the Live Bottom (Pinnacle Trend) Stipulation precludes platform installation within 30 m (100 ft) of a pinnacle feature, adverse effects to live-bottom features should be prevented.

Infrastructure or pipeline removal would impact the communities that have colonized the structures, many of which may also be found on live-bottom features. Removal of the structure itself would result in the removal of the hard substrate and the associated encrusting community. The overall community would experience a reduction in species diversity (both epifaunal encrusting organisms and the fish and large invertebrates that fed on them) with the removal of the structure (Schroeder and Love, 2004). The epifaunal organisms attached to the platform would die once the platform is removed. However, the seafloor habitat would return to the original soft-bottom substrate that existed before the well was drilled.

Some structures may be converted to artificial reefs. If the rig stays in place, the hard substrate and encrusting communities would remain part of the benthic habitat. The diversity of the community would not change and associated finfish species would continue to graze on the encrusting organisms. The community would remain an active artificial reef. However, plugging of wells and other reef-in-place decommissioning activities would still impact benthic communities as discussed above, since all the steps for removal except final removal from the water would still occur.

Proposed Action Analysis

The pinnacles in the CPA are located in the Main Pass, Viosca Knoll, and Destin Dome lease areas off Mississippi and Alabama within offshore Subareas C0-60 (east of the Mississippi River Delta) and C60-200. **Table 3-2** provides information regarding the level of proposed-action-related activities. For the CPA proposed action, 17-23 exploration/, 62-85 development wells, and 20-25 production structures are projected for offshore Subareas C0-60. There are 9-14 exploration/delineation, 23-33 development wells, and 2-3 production structures projected for offshore Subareas C60-200. It is unlikely that many of the wells or production structures would be located in the Pinnacle Trend area because pinnacle blocks make up only 2 percent of the blocks in Subarea C0-60 (eastern) and 6 percent of the blocks in Subarea C60-200. If the Live Bottom (Pinnacle Trend) Stipulation is implemented, pinnacle features would avoid incidences of anchor damage from support vessels. Furthermore, as noted above, any platforms in this region would be placed so as to avoid pinnacle features for safety reasons as well as environmental protection. Thus, anchoring events are not expected to impact the resource. Anchor impacts, however, could occur by mistake, with recovery taking a few to many years, depending on the severity (Fucik et al., 1984; Rogers and Garrison, 2001; Lissner et al., 1991).

Pipeline emplacement also has the potential to cause considerable disruption to the bottom sediments in the vicinity of the live bottoms (Chapter 4.1.1.8.1 of the Multisale EIS); however, the implementation of the proposed Live Bottom (Pinnacle Trend) Stipulation, or a similar protective measure, would restrict pipeline-laying activities as well as oil and gas activities in the vicinity of the pinnacle communities. Data gathered for the Mississippi-Alabama Continental Shelf Ecosystem Study (Brooks, 1991) and the Mississippi/Pinnacle Trend Ecosystem Monitoring, Final Synthesis Report (CSA and GERG, 2001) document dense biological communities (i.e., live-bottom communities, fish habitat, etc.) on the high- and medium-relief pinnacle features themselves and the live-bottom organisms more sparsely distributed in unconsolidated bottom sediments surrounding the pinnacles. The actual effect of pipeline-laying activities on the biota of the pinnacle communities would be restricted to the resuspension of sediments. Burial of pipelines is only required in water depths of 60 m (200 ft) or less. Therefore, only the shallowest live-bottom communities would be affected by the increased turbidity associated with pipeline burial. The laying of pipeline without burial produces much less resuspension of sediments. The

enforcement of the Live Bottom (Pinnacle Trend) Stipulation would help to minimize the impacts of pipeline-laying activities throughout the pinnacle region.

Summary and Conclusion

Oil and gas operations discharge drilling muds and cuttings that generate turbidity, potentially smothering benthos near the drill sites. Deposition of drilling muds and cuttings in the Pinnacle Trend area would not greatly impact the biota of the live bottoms because the biota surrounding the pinnacle features are adapted to turbid (nepheloid) conditions and high sedimentation rates associated with the outflow of the Mississippi River (Gittings et al., 1992a). The pinnacles themselves are coated with a veneer of sediment. Regional surface currents and water depth would largely dilute any effluent. Additional deposition and turbidity caused by a nearby well are not expected to adversely affect the pinnacle environment because such fluids would be dispersed upon discharge. Mud contaminants measured in the Pinnacle Trend region reached background levels within 1,500 m (4,921 ft) of the discharge point (Shinn et al., 1993). Toxic impacts on benthos are limited to within 100-200 m (328-656 ft) of a well (Montagna and Harper, 1996; Kennicutt et al., 1996), and NPDES permit requirements limit discharge. The drilling of a well from the proposed action, therefore, would have localized impacts on the benthos nearby the well, which should be located away from live-bottom features.

The toxicity of the produced waters has the potential to adversely impact the live-bottom organisms of the Pinnacle Trend; however, as previously stated, the proposed Live Bottom (Pinnacle Trend) Stipulation would prevent the placement of oil and gas facilities upon (and consequently would prevent the discharge of produced water directly over) the Pinnacle Trend live-bottom areas.

Platform removals have the potential to impact nearby habitats. As previously discussed, the platforms are unlikely to be constructed directly on the pinnacles or low-relief areas because of the restraints placed by the Live Bottom (Pinnacle Trend) Stipulation, distancing blasts from sensitive habitats. Benthic organisms on live bottoms should also have limited impact because they are resistant to blasts, tolerant of turbidity, can physically remove some suspended sediment, and may be located above or be tall enough to withstand limited sediment deposition. Live bottoms, however, may be impacted by heavy sediment deposition layers. The implementation of the Live Bottom (Pinnacle Trend) Stipulation would help to prevent such a smothering event. The proposed Live Bottom (Pinnacle Trend) Stipulation could prevent most of the potential impacts on live bottoms from bottom-disturbing activities (structure emplacement and removal) and operational discharges associated with the proposed action in the CPA. Any contaminants that reach live-bottom features would be diluted from their original concentration, so impacts that do occur should be sublethal.

Effects of the Proposed Action without the Proposed Stipulation

Activities resulting from the proposed action without the protection of the proposed Live Bottom (Pinnacle Trend) Stipulation (**Chapter 2.4.1.3.2**) could have an extremely deleterious impact on portions of the Pinnacle Trend areas. Mechanical damage from anchoring, drilling operations, and other installation activities is potentially the most damaging impact because these activities could destroy biological communities or damage the structure of the pinnacle areas themselves. This may in turn reduce the habitat or shelter areas occupied by commercial and recreational fishes. Those areas actually subjected to mechanical disruption would be severely impacted. Potential impacts on the Pinnacle Trend areas from other impact-producing factors associated with OCS activities (pipeline emplacement, discharges of muds and cuttings, and explosive structure removals) would damage live-bottom areas, particularly by smothering organisms with heavy layers of drilling muds and cuttings.

4.1.1.6.1.3. Impacts of Accidental Events

Background/Introduction

A detailed description of accidental impacts on live-bottom (Pinnacle Trend) communities can be found in Chapter 4.4.4.1.1 of the Multisale EIS and in Chapter 4.1.4.1.3 of the 2009-2012 Supplemental EIS. Chapter 2.4.1.3.2 of the Multisale EIS contains a complete description and discussion of the

proposed Live Bottom (Pinnacle Trend) Stipulation. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, which incorporates new information found since publication of the Multisale EIS and the 2009-2012 Supplemental EIS and in consideration of the DWH event.

The Pinnacle Trend, live-bottom features of the CPA that sustain sensitive offshore habitats are listed and described in **Chapter 4.1.1.6.1.1**. See **Chapter 2.4.1.3.2** for a complete description and discussion of the proposed Live Bottom (Pinnacle Trend) Stipulation.

Disturbances resulting from the CPA proposed action, including oil spills and blowouts, have the potential to disrupt and alter the environmental, commercial, recreational, and aesthetic values of live-bottom features of the CPA.

A search was conducted for additional new information published since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. Various Internet sources and journal articles were examined to discover any recent information regarding impacts of oil on benthic organisms. Sources investigated include literature published in journals and websites (NOAA, USEPA, and coastal universities). The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Possible Modes of Exposure

Oil released to the environment as a result of an accidental event may impact live-bottom features in several ways. Oil may be physically mixed into the water column from the sea surface, be injected below the sea surface and travel with currents, be dispersed in the water column, or be sedimented to particles and sink to the seafloor. These scenarios and their possible impacts are discussed in the following sections.

An oil spill that occurs at the sea surface would result in a majority of the oil remaining at the sea surface. Lighter compounds in the oil would evaporate, and some components of the oil may dissolve in the seawater. Evaporation removes the most toxic components of the oil, while dissolution may allow bioavailability of hydrocarbons to marine organisms for a brief period of time (Lewis and Aurand, 1997). The oil may also emulsify with water or sediment to particles and fall to the seafloor.

A spill that occurs below the sea surface (at the rig, along the riser between the seafloor and sea surface, or through leak paths on the BOP/wellhead) would result in only a portion of the released oil rising to the sea surface. If the leak is deep in the water column and the oil is ejected under pressure, oil droplets may become entrained deep in the water column (Boehm and Fiest, 1982). The upward movement of the oil may be reduced if methane in the oil is dissolved into the water column at the high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). Large oil droplets would rise to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume or the injection of dispersants, may remain neutrally buoyant in the water column, creating a subsurface plume (Adcroft et al., 2010). Oil droplets less than 100 μm (0.004 in) in diameter may remain in the water column for several months (Joint Analysis Group, 2010a).

Impacts that may occur to benthic communities on live-bottom features as a result of a spill would depend on the type of spill, distance from the spill, relief of the biological feature, and surrounding physical characteristics of the environment (e.g., turbidity). The Live Bottom (Pinnacle Trend) Stipulation requires a 30-m (100-ft) buffer around hard bottoms or pinnacle features to prevent seafloor impacts to the features and associated biota. This Agency created this stipulation to protect hard-bottom habitats from disruption due to oil and gas activities. However, oil released during accidental events may possibly reach live-bottom features. As described above, a portion of the oil released from a spill would rise to the sea surface, therefore reducing the impact to benthic communities by direct oil exposure. However, small droplets of oil that are entrained in the water column may migrate into live-bottom habitat. Although these small oil droplets would not sink themselves, they may also attach to suspended particles in the water column and then be deposited on the seafloor (McAuliffe et al., 1975). Exposure to subsea plumes, dispersed oil, or sedimented oil may result in long-term impacts such as reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. These impacts are discussed in the following sections.

Surface Slicks and Physical Mixing

Surface oil slicks can spread over a large area; however, the majority of the slick is comprised of a very thin surface layer of oil moved by winds and currents (Lewis and Aurand, 1997). Oil spills have the potential to foul benthic communities and cause lethal or sublethal effects to organisms that the oil contacts as it is moved over the sea surface. Pinnacles are features that rise up to as much as 20 m (66 ft) from the seafloor, at water depths between 60 and 120 m (200 and 400 ft) (Thompson et al., 1999; Schroeder, 2000). Pinnacles, therefore, are 40 m (130 ft) or more below the sea surface. The depth of live-bottom features below the sea surface helps protect benthic species from physical oil contact.

Field data collected at the Atlantic entrance to the Panama Canal 2 months after a tanker spill has shown that subtidal coral did not show measurable impacts to the oil spill, presumably because the coral was far enough below the surface oil and the oil did not contact the coral (Rützler and Sterrer, 1970). A similar result was reported from a Florida coral reef immediately following and 6 months after a tanker discharged oil nearby (Chan, 1977). The lack of acute toxicity was again attributed to the fact that the corals were completely submerged at the time of the spill, and calm conditions prevented the oil from mixing into the water column (Chan, 1977).

Disturbance of the sea surface by storms can mix surface oil into the water column, but the effects are generally limited to the upper 10-20 m (33-66 ft) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Therefore, the depth of live-bottom features below the sea surface should protect them from physical mixing of surface oil below the sea surface. However, if dispersants are used, they would enable oil to mix into the water column and possibly impact organisms on the live-bottom features. Dispersants are discussed later in this section.

Subsurface Plumes

A subsurface oil spill or plume could reach a live-bottom feature and would have the potential to damage the local biota contacted by oil. Such impacts on the biota may have severe and long-lasting consequences, including loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success.

Pinnacle features are protected from direct petroleum-producing impacts through the 30-m (100-ft) buffer distance as described in NTL 2009-G39 (USDOI, MMS, 2009b). The distancing of petroleum-producing activities from live-bottom features allows for several physical and biological changes to occur to the oil before it reaches sensitive benthic organisms. Oil would become diluted as it physically mixes with the surrounding water. The longer and farther a subsea plume travels in the sea, the more dilute the oil will be (Vandermeulen, 1982; Tkalich and Chan, 2002). In addition, microbial degradation of the oil occurs in the water column, reducing toxicity (Hazen et al., 2010; McAuliffe et al., 1981b). The oil will move in the direction of prevailing currents (S.L. Ross Environmental Research Ltd., 1997); however, data has indicated that currents move around large topographic features (Rezak et al., 1983; McGrail, 1982) and such movement would physically protect larger pinnacles and hard-bottom features by sweeping the subsea oil around the features rather than over them. Lower relief features may not experience such diversion of currents. Also, subsea oil plumes transported by currents may not travel nearly as far as surface oil slicks because some oil droplets may conglomerate and rise or may be blocked by fronts, as was observed in the southern Gulf of Mexico during the *Ixtoc* spill (Boehm and Fiest, 1982). Should any of the oil come in contact with adult sessile biota, effects would be primarily sublethal, as the oil may be diluted by physical and biological processes by the time it reaches the features. Some low-level exposure impacts may be chronic, while others may be temporary, and some may not even be able to be measured over time.

Although the Live Bottom (Pinnacle Trend) Stipulation protects benthic organisms from petroleum-producing activity, it is possible that low levels of oil transported in subsea plumes may reach benthic features. Several studies have reported results for oil impacts on both hermatypic and ahermatypic corals. Although not all of the same species studied are present on pinnacles, impacts are expected to be similar. For example, coral feeding activity may be reduced if it is exposed to low levels of oil. Experiments indicated that normal feeding activity of *Porites porites* and *Madracis asperula* were reduced when exposed to 50 ppm oil (Lewis, 1971). Tentacle pulsation of an octocoral, *Heteroxenia fuscescens*, has also been shown to decrease upon oil exposure, although recovery of normal pulsation was observed 96 hours after the coral was removed from the oil (Cohen et al., 1977). *Porites furcata* exposed to Marine

Diesel and Bunker C oil reduced feeding and left their mouths open for much longer than normal (Reimer, 1975).

Direct oil contact may result in coral tissue damage. Corals exposed to sublethal concentrations of oil for 3 months revealed atrophy of muscle bundles and mucus cells (Peters et al., 1981). *Porites furcata* submersed in Bunker C oil for 1 minute resulted in 100 percent tissue death, although the effect took 114 days to occur (Reimer, 1975).

Reproductive ability may also be reduced if coral is exposed to oil. A hermatypic coral, *Stylophora pistillata*, and an octocoral, *Heteroxenia fuscescens*, neither of which are present in the Gulf of Mexico, but may show impacts similar to those that could occur in the Gulf, shed their larvae when exposed to oil (Loya and Rinkevich, 1979; Rinkevich and Loya, 1977; Cohen et al., 1977). Undeveloped larvae in the water column have a reduced chance of survival due to predation and oil exposure (Loya and Rinkevich, 1979), which would in turn reduce the ability of larval settlement and reef expansion or recovery. A similar expulsion of gametes may occur in species that have external fertilization (Loya and Rinkevich, 1979), such as those at the Flower Garden Banks (Gittings et al., 1992c), which may then reduce gamete survivorship due to oil exposure.

The overall ability of a coral colony to reproduce may be affected by oil exposure. Reefs of *Siderastrea siderea* that were oiled in a spill produced smaller gonads than unoiled reefs, which resulted in reproductive stress for the oiled reef (Guzmán and Holst, 1993). *Stylophora pistillata* reefs exposed to oil had fewer breeding colonies, reduced number of ovaria per polyp, and significantly reduced fecundity compared with unoiled reefs (Rinkevich and Loya, 1977). Impaired development of reproductive tissue has also been reported for other reef-building corals exposed to sublethal concentrations of oil (Peters et al., 1981). Larvae may not be able to settle on substrate impacted by oil. Field experiments on *Stylophora pistillata* showed reduced settlement rate of larvae on artificial substrates of oiled reefs compared with control reefs and lower settlement rates, with increasing concentrations of oil in test containers (Rinkevich and Loya, 1977). Impaired larval settlement as a result of oiled substrate may lead to slow recovery of a disturbed substrate (CSA and GERG, 2001; MRRI, 1984; Montagna and Holmberg, 2000). Additionally, deeper habitats have slower rates of settlement, growth, and community development, and recruitment rates are reportedly slow in the pinnacle habitat (Montagna and Holmberg, 2000; CSA and GERG, 2001). It is possible that corals may not recruit to an oiled substrate for 10 years (MRRI, 1984).

Corals exposed to subsea oil plumes may also incorporate petroleum hydrocarbons into their tissue. Records indicate that *Siderastrea siderea*, *Diploria strigosa*, *Montastrea annularis*, and *Heteroxenia fuscescens* have accumulated oil from the water column and have incorporated petroleum hydrocarbons into their tissues (Burns and Knap, 1989; Knap et al., 1982; Kennedy et al., 1992; Cohen et al., 1977). Most of the petroleum hydrocarbons were incorporated into the coral tissues, not their mucus (Knap et al., 1982). However, hydrocarbon uptake may also modify lipid ratios of coral (Burns and Knap, 1989). If lipid ratios are modified, mucus synthesis may be impacted, adversely affecting coral ability to protect itself from oil through mucus production (Burns and Knap, 1989). While these species are not present in the Pinnacle Trend area, similar effects may occur in pinnacle species.

Sublethal effects, although often hard to measure, could be long lasting and affect the resilience of coral colonies to natural disturbances (e.g., elevated water temperature and diseases) (Jackson et al., 1989; Loya, 1976a). Continued exposure to oil from resuspended contaminated sediments could also impact coral growth and recovery (Guzmán et al., 1994). Any repetitive or long-term oil exposure could inhibit coral larvae's ability to settle and grow, may damage coral reproductive systems, may cause acute toxicity to larvae, and may physically alter the reef, interfering with larval settlement, all of which would reduce coral recruitment to an impacted area (Kushmaro et al., 1997; Loya, 1975 and 1976a; Rinkevich and Loya, 1977), Exposure of eggs and larvae to oil in the water column may reduce the success of a spawning event (Peters et al., 1997). Sublethal exposure to oil may be more detrimental to corals than high concentrations of oil (Cohen et al., 1977), as sublethal concentrations are typically more widespread and have a larger overall community effect. Therefore, the sublethal effects of oil exposure, even at very low concentrations, may result in compounded community impacts that have long-lasting effects.

Dispersed Oil

Chemically dispersed oil from a surface slick is not anticipated to result in lethal exposures to organisms on live-bottom features. The chemical dispersion of oil promotes the weathering process and increases the surface area available for bacterial biodegradation. It also allows surface oil to penetrate to greater depths than physical mixing would permit, and the dispersed oil will generally remain below the water's surface (McAuliffe et al., 1981b; Lewis and Aurand, 1997). However, reports on dispersant usage on surface plumes indicate that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to stick to particles in the water column, minimizing sedimented oil traveling to the seafloor (McAuliffe et al., 1981a; Lewis and Aurand, 1997).

Field experiments designed to test dispersant use on oil spills reported dispersed oil concentrations between 1 and 3 ppm, 9 m (30 ft) below the sea surface, approximately 1 hour after treatment with dispersant (McAuliffe et al., 1981a and 1981b). Other studies indicated that dispersed oil concentrations were <1 ppm, 10 m (33 ft) below the sea surface (Lewis and Aurand, 1997). The above data indicate that the mixing depth of dispersed oil is less than the depths of the crests of Pinnacle Trend features (40 m [130 ft] or more below the sea surface), greatly reducing the possibility of exposure to dispersed surface oil.

Any dispersed surface oil that may reach the benthic communities of live-bottom features in the Gulf of Mexico would be expected to be at very low concentrations (<1 ppm) (McAuliffe et al., 1981a). Such concentrations would not be life threatening to larval or adult stages based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed oil in the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms, such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Dispersants that are used on oil below the sea surface can travel with currents through the water and may contact benthic organisms on the live-bottom features. If the oil spill occurs near a live-bottom feature, the dispersed oil could be concentrated enough to harm the community. However, the longer the oil remains suspended in the water column traveling with currents, the more dispersed it would become. Weathering will also be accelerated and biological toxicity reduced (McAuliffe et al., 1981b). Although the use of subsea dispersants is a new technique and very little data are available on dispersion rates, it is anticipated that any oil that could reach live-bottom features on the continental shelf will be in low concentration based on surface slick dilution data (McAuliffe et al., 1981a; Lewis and Aurand, 1997). It is also anticipated that currents around the larger live-bottom features will sweep the subsea oil clear around the features (Rezak et al., 1983). Therefore, impacts resulting from exposure to dispersed oil are anticipated to be sublethal.

The report of damage to deepwater corals on the continental slope (USDOI, BOEMRE, 2010i) as a result of exposure to oil from the DWH probably resulted from the use of dispersant at the source of the blowout. This situation was the first time subsea dispersants were used, and stratified density layers of water allowed the oil plume to remain at depth instead of dispersing into the water column (Joint Analysis Group, 2010a). The density-bounded plume eventually contacted the coral. The decision to use subsea dispersants at the DWH was carefully weighed against the surrounding environment and anticipated environmental impacts. The decision to use subsea dispersants may not occur near protected habitats. For example, NOAA policy says that the application of dispersants must occur as far as possible from the Flower Garden Banks (Gittings, 2006). Also, because a stratified turbid watermass (the nepheloid layer) occurs near the seafloor on the continental shelf in the northwestern Gulf of Mexico no more than 20 m (66 ft) up into the water column, a depth that may engulf part or all of a live-bottom feature, decisionmakers probably would not select to use dispersants near the habitat.

Sublethal impacts that may occur to coral and other invertebrates exposed to dispersed oil may include reduced feeding, reduced photosynthesis, reduced reproduction and growth, physical tissue damage, and altered behavior. Short-term, sublethal responses of *Diploria strigosa* were reported after exposure to dispersed oil at a concentration of 20 ppm for 24 hours (Knap et al., 1983; Wyers et al., 1986). Although concentrations in this experiment were higher than what is anticipated for dispersed oil at depth, effects included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction,

localized tissue rupture (Wyers et al., 1986), and a decline in tentacle expansion behavior (Knap et al., 1983). Normal behavior resumed within 2 hours to 7 days after exposure (Wyers et al., 1986; Knap et al., 1983). This coral, however, did not show indications of stress when exposed to 1 ppm and 5 ppm of dispersed oil for 24 hours (Wyers et al., 1986). *Diploria strigosa* exposed to dispersed oil (20:1, oil: dispersant) showed an 85 percent reduction in zooxanthellae photosynthesis after 8 hours of exposure to the mixture (Cook and Knap, 1983). However, the response was short-term, as recovery occurred between 5 and 24 hours after exposure and return to clean seawater. Investigations 1 year after *Diploria strigosa* was exposed to concentrations of dispersed oil between 1 and 50 ppm for periods between 6 and 24 hours did not reveal any impacts to growth (Dodge et al., 1984; Knap et al., 1983). It should be noted, however, that subtle growth effects may have occurred, but they were not measurable (Knap et al., 1983). This type of short-term exposure matches anticipated exposures, if any, to pinnacle features. Subsea oil plumes from a spill could be carried by currents to the features but would pass by or change directions, resulting in only short-term contact with any particular benthic feature. Many benthic organisms would return to normal in a few hours to days.

Historical studies indicated that dispersed oil appeared to be more toxic to coral species than oil or dispersant alone. The greater toxicity may be a result of an increased number of oil droplets, resulting in greater contact area between oil and water (Elgershuizen and De Kruijf, 1976). The dispersant causes a higher water soluble fraction of oil contacting the cell membranes of the coral (Elgershuizen and De Kruijf, 1976). The mucus produced by coral, however, can protect an organism from oil. Both hard and soft corals have the ability to produce mucus; mucus production has been shown to increase when corals are exposed to crude oil (Mitchell and Chet, 1975; Ducklow and Mitchell, 1979). Dispersed oil, which has very small oil droplets, does not appear to adhere to coral mucus, and larger untreated oil droplets may become trapped by the mucus barrier (Knap, 1987; Wyers et al., 1986). However, entrapment of the larger oil droplets may increase long-term exposure to oil if the mucus is not shed in a timely manner (Knap, 1987; Bak and Elgershuizen, 1976).

More recent field studies did not reveal as great an impact of dispersants on corals as were indicated in historical toxicity tests (Yender and Michel, 2010). This difference in reported damage probably resulted from a more realistic application of dispersants in an open field system and because newer dispersants are less toxic than the older ones (Yender and Michel, 2010). Field studies have shown oil to be dispersed to the part per billion level minutes to hours after the dispersant application, which is orders of magnitude below the reasonable effects threshold of oil in the water column (20 ppm) measured in some studies (McAuliffe, 1987; Shigenaka, 2001).

Although dispersed oil may be more toxic than untreated oil to corals during exposure experiments (Shafir et al., 2007; Wyers et al., 1986; Cook and Knap, 1983), untreated oil may remain in the ecosystem for long periods of time, while dispersed oil does not (Baca et al., 2005; Ward et al., 2003). Twenty years after an experimental oil spill in Panama, oil and impacts from untreated oil were still observed at oil treatment sites, but no oil or impacts were observed at dispersed oil or reference sites (Baca et al., 2005). Long-term recovery of the coral at the dispersed oil site had already occurred as reported in a 10-year monitoring update, and the site was not significantly different from the reference site (Ward et al., 2003).

The time of year and surrounding ecosystem must be considered when determining if dispersants should be used. Dispersant usage may result in reduced or shorter term impacts to coral reefs; however, it may increase the impacts to other communities, such as mangroves (Ward et al., 2003). Therefore, dispersant usage may be more applicable offshore than in coastal areas where other species may be impacted as well. Dispersants also would probably not be approved during peak coral spawning periods (e.g., August-September for major reef-building species) (Gittings et al., 1992c and 1994) in order to limit the impacts of oil pollution on the near-surface portion of the water column.

Sedimented Oil (Oil Adsorbed to Sediment Particles)

Smaller suspended oil droplets could be carried to the seafloor as a result of oil droplets adhering to suspended particles in the water column. Smaller particles have a greater affinity for oil (Lewis and Aurand, 1997). Oiled sediment that settles to the seafloor may affect organisms attached to live-bottom features. It is anticipated that the greatest amount of sedimented oil would occur close to the spill, with lesser concentrations farther from the source. Studies after a spill that occurred at the Chevron Main Pass Block 41C Platform in the northern Gulf of Mexico revealed that the highest concentrations of oil in the

sediment were close to the platform and the oil settled to the seafloor within 5-10 mi (8-16 km) of the spill site (McAuliffe et al., 1975). Therefore, if the spill occurs close to a live-bottom feature, the underlying benthic communities may be exposed to toxic hydrocarbons. However, because of the implementation of the 30-m (100-ft) buffer zone around pinnacles features, these hard-bottom communities should be distanced from the heaviest oiled sedimentation effects.

Some oiled particles may become widely dispersed as they travel with currents while they settle out of suspension. Settling rates are determined by size and weight of the particle, salinity, and turbulent mixing in the area (Poirier and Thiel, 1941; Bassin and Ichiye, 1977; Deleersbijder et al., 2006). Because particles would have different sinking rates, the oiled particles would be dispersed over a large area, most likely at sublethal or immeasurable levels. Studies conducted after the *Ixtoc* oil spill revealed that, although oil was measured on particles in the water column, measurable petroleum levels were not found in the underlying sediment (ERCO, 1982). Based on BOEMRE restrictions and the settling rates and behavior of sedimented oil, the majority of organisms that may be exposed to sedimented oil are anticipated to experience low-level concentrations.

Sublethal impacts to benthic organisms may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. Experiments have shown that the presence of oil on available substrate for larval coral settlement has inhibited larval metamorphosis and larval settlement (Kushmaro et al., 1997). Crude oil concentrations as low as 0.1 ppm on substrate upon which the coral larvae were to settle reduced larval metamorphosis occurrences by 50 percent after 8 days of exposure. Oil concentrations of 100 ppm on substrates resulted in only 3.3 percent of the test population metamorphosizing (Kushmaro et al., 1997). There was also an increased number of deformed polyps after metamorphosis due to oil exposure (Kushmaro et al., 1997). It is also possible that recurring exposure may occur to coral if sedimented oil is resuspended locally, possibly inhibiting coral growth and recovery in the affected areas (Guzmán et al., 1994). Oil stranded in sediment is reportedly persistent and does not weather much (Hua, 1999), so coral may be repeatedly exposed to elevated concentrations of oil.

Adult coral, however, may be able to protect itself from low concentrations of sedimented oil through mucus production. Coral mucus may not only act as a barrier to protect coral from the oil in the water column, it has been shown to aid in the removal of oiled sediment on coral surfaces (Bak and Elgershuizen, 1976). Coral may use a combination of increased mucus production and ciliary action to rid themselves of oiled sediment (Bak and Elgershuizen, 1976).

Blowout and Sedimentation

Oil or gas well blowouts are possible occurrences in the OCS. Benthic communities exposed to large amounts of resuspended sediments following a subsurface blowout could be subject to sediment suffocation, exposure to toxic contaminants, and reduced light. Should oil or condensate be present in the blowout flow, liquid hydrocarbons could be an added source of negative impact on the benthos.

Turbid waters allow less light penetrating to depth, which may result in reduced photosynthesis by the symbiotic zooxanthellae that live in hermatypic coral tissue and by calcareous algae (Rogers, 1990). Long-term exposures to turbidity have even resulted in significantly reduced skeletal extension rates in the scleractinian coral *Montastraea annularis* (Torres, 2001; Dodge et al., 1974) and acute decrease in calcification rates of *Madracis mirabilis* and *Agaricia agaricites* (Bak, 1978). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Suspended sediment that is transported by currents deep in the water column would not impact the benthic organisms on live-bottom features. Studies have shown that deep currents sweep around topographic features instead of over them, allowing the suspended sediment to remain at depth (Rezak et al., 1983; McGrail, 1982). A similar movement of water is anticipated around larger pinnacle features; therefore, suspended sediment or subsea oil plumes from depth would not be deposited on top of the elevated benthic organisms. However, lower relief features may experience slightly more deposition as currents may not sweep around them as much as the higher relief features.

Sediment that settles out of upper layers of the water column may impact benthic organisms of live-bottom features. Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, reducing light intensity, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced colony coverage, changes in species diversity and

dominance patterns, alterations in growth rates and forms, decreased calcification, decreased photosynthesis, increased respiration, increased production in mucus, loss of zooxanthellae, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may also be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008). Gorgonian larvae, for example, only settle on substrate that does not have accumulated sediment (Grigg, 1977).

Impacts to corals as a result of sedimentation would vary based on coral species, the height to which the coral grows, degree of sedimentation, length of exposure, and the coral's ability to clear the sediment. Impacts may range from sublethal effects such as reduced growth, alteration in form, reduced recruitment and productivity, and slower growth to death (Rogers, 1990).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Scleractinian corals are tolerant of short-term sediment exposure and burial, but longer exposures may result in the loss of zooxanthellae, polyp swelling, increased mucus production, reduced coral growth, and reduced reef development (Marszalek, 1981; Rice and Hunter, 1992). Bleached tissue as a result of sediment exposure has been reported to recover in approximately a month (Wesseling et al., 1999).

Solitary octocorals and gorgonians, which are abundant on many hard-bottom features, are more tolerant of sediment deposition than colony-forming scleractinian corals because the solitary species grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a). Many of these organisms have even been observed to grow tall enough to resist burial during periods of sediment encroachment (Lissner et al., 1991). Branching and upright forms of scleractinian corals, such as *Madracis mirabilis* and *Agaricia agaricites*, also tend to be more tolerant of sediment deposition than massive, plating, and encrusting forms, such as *Porites astreoides* (Roy and Smith, 1971; Bak, 1978). Some of the more sediment-tolerant scleractinian species in the Gulf of Mexico include *Montastraea cavernosa*, *Siderastrea siderea*, *Siderastrea radians*, and *Diploria strigosa* (Torres et al., 2001; Acevedo et al., 1989; Loya, 1976b). Due to the influence of the Mississippi River in the CPA, waters are more turbid near the outflow of the River, and more turbidity-tolerant species are present on live bottoms in this portion of the Gulf of Mexico. Because many of the species are more tolerant of turbidity and sedimentation, they could better survive exposure to increased sediment input (Gittings et al., 1992a).

Since BOEMRE's proposed stipulation would preclude drilling within 30 m (100 ft) of a pinnacle feature, most adverse effects on live-bottom features from blowouts would likely be prevented. Petroleum-producing activities would be far enough removed that heavy layers of sediment suspended as a result of a blowout should settle out of the water column before they reach sensitive biological communities. Other particles that travel with currents should become dispersed as they travel, reducing turbidity and depositional impacts. Furthermore, sediment traveling at depth should remain at depth instead of rising to the top of live-bottom features.

Response Activity Impacts

Oil-spill-response activity may also impact sessile benthic features. Booms anchored to the seafloor are sometimes used to control the movement of oil at the water surface. Boom anchors can physically impact corals and other sessile benthic organisms, especially when booms are moved around by waves (Tokotch, 2010). Vessel anchorage and decontamination stations set up during response efforts may also break or kill hard-bottom features as a result of setting anchors. Anchor damage may result in the crushing and breaking of hard bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary species (cup corals, octocorals, and hydrocorals), may recolonize areas more rapidly than slow-growing colonial forms that disperse larval great distances (Lissner et al., 1991). Effort should be made to keep vessel anchorage areas away from sensitive benthic features to minimize impact.

Drilling muds comprised primarily of barite may be pumped into a well to stop a blowout. If a "kill" is not successful, the mud may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath the extruded drilling mud would be buried. Based on the BOEMRE stipulation contained in NTL 2009-G39, a well should be far enough away from live-bottom features to prevent extruded drilling muds from smothering sensitive benthic communities. However, if drilling muds were to travel far enough or high enough in the water column to contact a hard-bottom community, the fluid may smother the existing community. Low-relief communities would be more at risk for burial than the higher pinnacles. Experiments indicate that corals perish faster when buried beneath drilling mud than when buried beneath carbonate sediments (Thompson, 1979). Turbidity impacts may result in reduced photosynthesis or reduced growth (Rogers, 1990; Torres, 2001). Light layers of deposited sediment would most likely be removed by mucus and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995).

Proposed Live Bottom (Pinnacle Trend) Stipulation

The proposed Live Bottom (Pinnacle Trend) Stipulation is a potential mitigating measure for leases resulting from the proposed action. The stipulation is designed to prevent petroleum-producing activities from damaging the pinnacle features. Under the stipulation, plans will be reviewed on a case-by-case basis to determine whether a proposed operation could impact a pinnacle area. If it is determined from site-specific information derived from BOEMRE studies, published information from other research programs, geohazards survey information, or another source that the operation would impact a pinnacle area, the operator may be required to relocate the proposed operation.

Although the BOEMRE stipulation prevents oil and gas drilling activity within 30 m (100 ft) of pinnacle features, some effects may occur to benthic organisms as a result of an oil spill. Sublethal impacts may include exposure to low levels of oil, dispersed oil, or sedimented oil and turbidity and sedimentation from disturbed sediments. Effects from these exposures may include reduced photosynthesis, reduced growth, altered behavior, decreased community diversity, altered community composition, reduction in coral cover, and reduced reproductive success. The severity of these impacts may be dependent on the concentration and duration of exposure. If concentrated oil is carried to live-bottom habitats in a subsea plume, severe lethal effects could result to localized community habitats (Dodge et al., 1984; Wyers et al., 1986). Recovery could take 10 years or more (MRRI, 1984; Fucik et al., 1984; Rogers and Garrison, 2001).

Proposed Action Analysis

The Pinnacle Trend occupies 74 lease blocks in the northeastern portion of the CPA proposed action and is protected from impacts from oil and gas activity. The Pinnacle Trend blocks represent a small fraction of the continental shelf area in the CPA. The fact that the Pinnacle Trend features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the Pinnacle Trend.

The shallowest water depth over any features of the Pinnacle Trend in the CPA is about 60 m (200 ft). When surface spills are mixed into the water column, the oil is not expected to penetrate below a depth of about 10 m (33 ft). The use of dispersants could result in oil mixing into the water column and potentially reaching Pinnacle Trend communities.

With the application of the proposed Live Bottom (Pinnacle Trend) Stipulation, blowouts would not occur within 30 m (100 ft) of a Pinnacle Trend feature. Furthermore, blowouts near Pinnacle Trend features would be unlikely to impact the biota because oil would rapidly float to the surface. Oil that is ejected under pressure may produce tiny droplets that become entrained in the water column and could possibly affect the Pinnacle Trend communities. Sedimented oil or sedimentation as a result of a blowout near a Pinnacle Trend community may impact benthic organisms.

Potential impacts to the Pinnacle Trend from oil spills and blowouts from the CPA proposed action are unlikely and are not expected to be significant. Chemical spills are also infrequent, of small quantity, and usually occur in surface waters. The proposed Live Bottom (Pinnacle Trend) Stipulation would assist in preventing most of the potential impacts from oil and gas operations, including accidental oil spills, blowouts, and chemical spills on the biota of the Pinnacle Trend. No significant impacts to the Pinnacle Trend are expected from the CPA proposed action.

Summary and Conclusion

Live-bottom features represent a small fraction of the continental shelf area in the CPA. The fact that the live-bottom features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the live-bottom features.

The proposed Live Bottom (Pinnacle Trend) Stipulation (**Chapter 2.4.1.3.2**) would prevent most of the potential impacts from oil and gas operations, including accidental oil spills and blowouts, on the biota of live-bottoms features. However, operations outside the proposed buffer zones around sensitive habitats (including blowouts and oil spills) may affect live-bottom features.

The depth below the sea surface to which many live-bottom features rise helps to protect them from surface oil spills. Some pinnacles may rise to within 40 m (130 ft) of the sea surface; however, many features have much less relief or are in deeper water depths. Any oil that might contact pinnacle features would probably be at low concentrations because the depth to which surface oil can mix down into the water column is less than the peak of the tallest pinnacles, and this would result in little effect to these features.

A subsurface spill or plume may impact sessile biota of live-bottom features. Oil or dispersed oil may cause sublethal impacts to benthic organisms if a plume reaches these features. Impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. The Live Bottom (Pinnacle Trend) Stipulation would limit the potential impact of such occurrences by keeping the sources of such adverse events geographically removed from the sensitive biological resources of live-bottom features.

Sedimented oil or sedimentation as a result of a blowout may impact benthic organisms. However, because the Live Bottom (Pinnacle Trend) Stipulation places petroleum-producing activity at a distance from live-bottom features, this would result in reduced turbidity and sedimentation. Furthermore, any sedimented oil should be well dispersed, resulting in a light layer of deposition that would be easily removed by the organism and have low toxicity.

The proposed Live Bottom (Pinnacle Trend) Stipulation would assist in preventing most of the potential impacts on live-bottom communities from blowouts, surface, and subsurface oil spills and the associated effects. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a live-bottom feature, the effects would be primarily sublethal and impacts would be at the community level. Any turbidity, sedimentation, and sedimented oil would also be at low concentrations by the time the live-bottom features were reached, resulting in sublethal impacts.

Effects of the Proposed Action without the Proposed Stipulation

The live-bottom features and associated biota of the CPA could be adversely impacted by oil and gas activities resulting from the proposed action should it not be restricted by the proposed Live Bottom (Pinnacle Trend) Stipulation. This would be particularly true should operations occur directly on top of or in the immediate vicinity of otherwise protected live-bottom features. The area within the restricted zones would probably be the areas of the live-bottom features that are most susceptible to adverse impacts if oil and gas activities are not restricted by the Live Bottom (Pinnacle Trend) Stipulation or project-specific mitigating measures. These impacting factors would include blowouts, surface oil spills, and subsea oil spills. Potential impacts from routine activities resulting from the proposed action are discussed in **Chapter 4.1.1.6.1.2**.

Oil spills as well as routine activities have the potential to considerably alter the diversity, cover, and long-term viability of the biota found on live-bottom features. Direct oil contact may result in acute toxicity (Dodge et al., 1984; Wyers et al., 1986). In most cases, recovery from disturbances would take 10 years or more (MRRI, 1984; Fucik et al., 1984; Rogers and Garrison, 2001). Indeed, disturbances, including oil spills and blowouts, would alter benthic substrates and their associated biota over large areas. In the unlikely event of a blowout, sediment resuspension (potentially with associated oil) could cause adverse turbidity and sedimentation conditions. In addition to affecting the benthic cover of a live-bottom feature, a blowout could alter the local benthic morphology, thus irreversibly altering the live-bottom community. Oil spills (surface and subsea) could be harmful to the local biota should the oil have a prolonged or recurrent contact with the organisms. Therefore, in the absence of the Live Bottom

(Pinnacle Trend) Stipulation, the proposed action could cause long-term (10 years or more) adverse impacts to the biota of the live-bottom features.

4.1.1.6.1.4. Cumulative Impacts

Background/Introduction

A detailed description of cumulative impacts on live-bottom (Pinnacle Trend) communities can be found in Chapter 4.5.4.1.1 of the Multisale EIS and in Chapter 4.1.4.1.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, which incorporates new information found since publication of the Multisale EIS and the 2009-2012 Supplemental EIS and in consideration of the DWH event.

This cumulative analysis considers the effects of impact-producing factors related to the proposed action plus those related to prior and future OCS lease sales, and to tanker and other shipping operations that may occur and adversely affect live bottoms of the Pinnacle Trend area. Specific OCS-related, impact-producing factors considered in the analysis are structure emplacement and removal, anchoring, discharges from well drilling, produced waters, pipeline emplacement, oil spills, blowouts, and operational discharges. Non-OCS-related impacts including commercial fisheries, natural disturbances, anchoring by recreational boats, and other non-OCS commercial vessels, as well as spillage from import tankering, all have the potential to alter live bottoms.

It is assumed that the Live Bottom (Pinnacle Trend) Stipulation for live bottoms would be part of appropriate OCS leases and that existing site/project-specific mitigations would be applied to OCS activities on these leases or supporting activities on these leases. The Live Bottom (Pinnacle Trend) Stipulation does not permit bottom-disturbing activities within 30 m (100 ft) of any hard bottom or pinnacle. However, stipulations and mitigations do not protect the resources from activities outside of BOEMRE jurisdiction (i.e., commercial fishing, tanker and shipping operations, or recreational activities).

Severe and permanent physical damage may occur to pinnacle features and the associated live bottoms as a result of non-OCS activities. It is assumed those biota associated with live bottoms of the CPA are well adapted to natural disturbances such as turbidity and storms; however, human disturbance could cause severe damage to live-bottom biota, possibly leading to changes of physical integrity, species diversity, or biological productivity. If such events were to occur, recovery to pre-impact conditions could take as much as 10 years (Fucik et al., 1984).

Natural events such as storms, extreme weather, and fluctuations of environmental conditions (e.g., nutrient pulses, low dissolved oxygen levels, seawater temperature minima, and seasonal algal blooms) may impact live-bottom communities. Because of the depth of the Pinnacle Trend environment, waves seldom have a direct influence. During severe storms, such as hurricanes, large waves may reach deep enough to stir bottom sediments (Brooks, 1991; CSA, 1992a). These forces are not expected to be strong enough to cause direct physical damage to organisms living on the features. Rather, currents are created by the wave action that can resuspend sediments to produce added turbidity and sedimentation (Brooks, 1991; CSA, 1992a). The animals in this region are well-adapted to the effects common to this frequently turbid environment (Gittings et al., 1992a).

Recreational boating, fishing, and import tankering may severely impact live-bottom communities. Ships anchoring near major shipping fairways of the CPA or EPA, on occasion, may impact sensitive areas located near these fairways. Numerous fishermen also take advantage of the resources of the region and may anchor at hard-bottom locations to fish. Much of the fishing on these habitats uses bottom fishing gear that may damage benthic organisms or may snag on the reefs and be lost. Such gear, particularly lines of varying thickness, can cut into the tissues of many benthic organisms during storm movement of bottom waters.

Damage resulting from commercial fishing, especially bottom trawling, may have a severe impact on hard-bottom benthic communities. Bottom trawling in the Gulf of Mexico primarily targets shrimp from nearshore waters to depths of approximately 90 m (300 ft) (NRC, 2002). Although trawlers would not target areas with pinnacles as fishing ground, since pinnacles may tangle with gear, accidental instances of trawling may occur near or over pinnacles, resulting in community damage. Reports indicate that bottom trawling activity on hard-bottom substrates can overturn boulders and destroy epifaunal organisms (Freese et al., 1999). Large emergent sponges and anthozoans may be particularly vulnerable to trawling

activity, as these organisms grow above the substrate and can be caught and removed by trawling activity (Freese et al., 1999). Recovery rates of corals and coralline algae may take decades to centuries and depend on the extent of the impact, frequency of disturbance, other natural changes that occur to the habitat, and the organism's life history (NRC, 2002).

Structure placement and anchor damage from support boats and ships, floating drilling units, and pipeline-laying vessels that disturb areas of the seafloor are considered the greatest oil and gas OCS-related threat to pinnacle live-bottom areas. The size of the areas affected by chains associated with anchors and pipeline-laying barges would depend on the water depth, chain length, sizes of anchor and chain, method of placement, wind, and current (Lissner et al., 1991). Anchor damage could include crushing and breaking of live bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years from which to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary species (cup corals, octocorals, and hydrocorals), may recolonize areas more rapidly than slow-growing colonial forms that disperse larval great distances (Lissner et al., 1991). Such anchoring damage, however, should be minimized on pinnacle habitats, as no bottom-disturbing activities are permitted within 30 m (100 ft) of the hard-bottom feature, as described by NTL 2009-G39 (USDOI, MMS, 2009b).

Both explosive and nonexplosive structure-removal operations disturb the seafloor; however, they are not expected to affect hard-bottom communities because of required buffer distances and because many sessile benthic organisms are known to resist the concussive force of structure-removal-type blasts (O'Keeffe and Young, 1984). Also, BOEMRE regulations require charges to be detonated 5 m (15 ft) below the mudline, which would attenuate shock waves in the seafloor (Baxter et al., 1982). Should pinnacle communities incur any damages as a result of the explosive removal of structures, recruitment and succession of the communities would be slow and may take more than 10 years (Montagna and Holmberg, 2000; CSA and GERG, 2001; MRRI, 1984).

Routine discharges of drilling muds and cuttings by oil and gas operations could affect biological communities and organisms through a variety of mechanisms, including the smothering of organisms through deposition or less obvious sublethal toxic effects (impacts to growth and reproduction). The Live Bottom (Pinnacle Trend) Stipulation, however, require that drilling occur at least 30 m (100 ft) from pinnacles, which helps protect these features through physical distance from wells. Even though the additive effects of drilling several wells add more discharges to the environment, the Live Bottom (Pinnacle Trend) Stipulation protects these sensitive communities through distance from drilling.

Drilling muds quickly disperse upon release, and most of the material is rapidly deposited on the seafloor (Neff, 2005; Shinn et al., 1980; Hudson et al., 1982). The drilling fluid plume in the water column has been measured to be only a few milligrams/liter above background sediment concentrations 100 m (328 ft) from the discharge point, concentrations often less than those produced during storms or from boat wakes (Shinn et al., 1980). Deposition of drilling muds and cuttings in pinnacle habitats are not expected to greatly impact the biota of the surrounding habitat for two reasons. First, the biota that live on the pinnacles are adapted to turbid conditions and storm impacts (Gittings et al., 1992a), reducing their vulnerability to sedimentation. Second, BOEMRE policy does not allow drilling within 30 m (100 ft) of a pinnacle, placing physical distance between the well and the sensitive environment in which the cuttings may travel to the seafloor. Any exposure that may occur from muds and cuttings discharged as a result of the cumulative scenario would be temporary, primarily sublethal in nature, and the effects would be limited to small areas. Recovery to pre-impact conditions from these sublethal impacts would take place within 10 years (Fucik et al., 1984).

Produced waters from petroleum operations are not likely to have a great impact on pinnacles. Produced waters are rapidly diluted and impacts are generally only observed within proximity of the discharge point, and acute toxicity that may result from produced waters occurs "within the immediate mixing zone around a production platform" (Gittings et al., 1992b; Holdway, 2002). There have been no reported impacts to marine organisms or sediment contamination beyond 100 m (328 ft) of the produced-water discharge (Neff and Sauer, 1991; Trefry et al., 1995). Rapid dilution of surface discharges was reported within 6 m (20 ft) from the release point (Shinn et al., 1980; Hudson et al., 1982). Drilling

discharges may be diluted 100 times at 10 m (33 ft) from the discharge and 1,000 times at 100 m (328 ft) from the discharge (Neff, 2005). Dilution continues with distance from the discharge point; at 96 m (315 ft) from the release point, Shinn et al. (1980) measured a plume as only a few milligrams/liter above background suspended sediment concentrations. Suspended sediment concentrations 6 m (20 ft) from the discharge were often less than those produced during storms or from boat wakes (Shinn et al., 1980). Similar dilution factors can be expected for produced-water discharges. Because BOEMRE policy does not allow drilling within 30 m (100 ft) of a pinnacle, the possibility of acute toxicity from the discharge is eliminated. If any impacts were to occur, they would be sublethal.

The Live Bottom (Pinnacle Trend) Stipulation and site-specific mitigations are expected to prevent operators from placing pipelines directly upon live-bottom communities. The effect of pipeline-laying activities on the biota of these communities would be restricted to the resuspension of sediments, possibly causing obstruction of filter-feeding mechanisms of sedentary organisms and gills of fishes. Adverse impacts from resuspended sediments would be temporary, primarily sublethal in nature, and the effects would be limited to small areas. Impacts may include "changes in respiration rate, . . . abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus" (Anchor Environmental CA, L.P., 2003). Since burial of pipelines is not required in water depths >60 m (200 ft), very little of the Pinnacle Trend area (≥ 60-m [200-ft] depth) would be subjected to high turbidity caused by burial during pipeline-laying activities.

The Live Bottom (Pinnacle Trend) Stipulation would help protect hard-bottom communities from experiencing direct oiling as a result of a blowout because bottom-disturbing activities are not permitted within 30 m (100 ft) these communities. Also, the depth of pinnacle features (60-120 m; 200-400 ft) helps protect them from fouling by oil. Disturbance of the sea surface by storms can mix surface oil into the water column, but the effects are generally limited to the upper 10-20 m (33-66 ft) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Pinnacles rise up to 20 m (66 ft) above the seafloor, at water depths between 60 and 120 m (200 and 400 ft) (Thompson et al., 1999; Schroeder, 2000). Pinnacles, therefore, are 40 m (130 ft) or more below the sea surface. The depth of the live-bottom features below the sea surface helps protect benthic species from physical oil contact.

Any dispersed surface oil from a tanker or rig spill that may reach the benthic communities of pinnacles in the Gulf of Mexico would be expected to be at very low concentrations (less than 1 ppm) (McAuliffe et al., 1981a and 1981b; Lewis and Aurand, 1997). Such concentrations would not be life threatening to larval or adult stages based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed or physically mixed oil in the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms, such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Potential blowouts are unlikely to impact the biota of the pinnacles unless dispersants are used because BOEMRE policy does not allow drilling within 30 m (100 ft) of a pinnacle. Therefore, these sensitive habitats are distanced from the potential lethal impacts of a blowout. Oil leaked at the seafloor would rise to the sea surface because all known reserves in the Gulf of Mexico have specific gravity characteristics that would preclude oil from sinking immediately after release at a blowout site. If any blowouts from wells did occur, the suspended sediments should settle out of the water column before a majority of the material reached a pinnacle. Any oil that becomes entrained in a subsurface plume will be dispersed as it travels in the water column (Vandermeulen, 1982; Tkalich and Chan, 2002). Also, because currents are anticipated to sweep around the larger pinnacle features instead of over them, subsea oil should be directed away from the larger features (Rezak et al., 1983; McGrail, 1982). If oil were to contact the live-bottom features, concentrations would be sublethal unless the source is close to the feature; the impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. In the highly unlikely event that oil from a subsurface spill could reach a coral covered area in lethal concentrations, the recovery of this area could take in excess of 10 years (Fucik et al., 1984).

In the unlikely event a freighter, tanker, or other oceangoing vessel related to OCS Program activities sank and collided with pinnacle features or associated habitat, releasing its cargo, recovery capabilities from such a catastrophic scenario are unknown at this time. For the purpose of this analysis, it is

projected that no surface spills, regardless of size, would have an impact on the biota of pinnacles, largely because the tops of the features crest at depths greater than 40 m (130 ft) below the sea surface. Surface oil spills are therefore not expected to impact the pinnacle communities, as discussed above.

Should the Live Bottom (Pinnacle Trend) Stipulation not be implemented for the proposed action or for future lease sales, OCS activities could have the potential to destroy part of the biological communities and damage one or several live/hard-bottom features. The most potentially damaging of these are the impacts associated with physical damages that may result from anchors, structure emplacement, and other bottom-disturbing operations.

A recent report documents damage to a deepwater coral community 7 mi (11 km) southwest of the DWH event. Results are still pending, but it appears that a deepwater coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged (USDOI, BOEMRE, 2010j). Surface oil was also reported above some pinnacle features; however, results of field studies in the area are pending at this time (Boland et al., 2010).

The cumulative impact of possible oil spills, along with the DWH event, is not anticipated to affect the overall Pinnacle Trend habitat. The limited data currently available on the impacts of the DWH event make it difficult to definitively say if any impacts have affected the pinnacle features. It appears some impacts have occurred to corals within 7 mi (11 km) of the well. Water column sampling, however, indicated that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm, 40 and 45 nmi (74 and 83 km; 46 and 52 mi) northeast of the well (Haddad and Murawski, 2010), which is below concentrations known to cause acute toxicity, and are more likely to cause low-level, short-term impacts to corals (Dodge et al., 1984; Wyers et al., 1986; Kushmaro et al., 1997). If oil is released near a pinnacle feature and concentrated oil is entrained in the water column (by turbulent discharge or use of dispersant), it could contact nearby pinnacle habitat with serious detrimental effects. Habitats receiving high concentrations of oil could take 10 or more years to recover (Fucik et al., 1984). However, since subsea plumes travel directionally with water currents, only pinnacle habitats directly in the path of the plume would be affected. Therefore, the acute impacts of any large-scale blowout would likely be limited in scale, and any additive impacts of several blowouts should only impact small areas on an acute level, with possible sublethal impacts occurring over a larger area. However, BOEMRE policy would not allow wells to be drilled within 30 m (100 ft) of a pinnacle, separating the habitat from the worst of the sediment deposition and allowing most of the oil to rise to the sea surface without contacting pinnacle features.

Summary and Conclusion

Non-OCS activities that may occur in the vicinity of the pinnacle communities include recreational boating and fishing, import tankering, and natural events such as extreme weather conditions, and extreme fluctuations of environmental conditions. These activities could cause damage to the pinnacle communities. Ships using fairways in the vicinity of pinnacles anchor in the general area of pinnacles on occasion, and numerous fishermen take advantage of the resources of regional bottoms. These activities could lead to instances of severe and permanent physical damage. During severe storms, such as hurricanes, large waves may reach deep enough to stir bottom sediments (Brooks, 1991; CSA, 1992a). Because of the depth of the Pinnacle Trend area, these forces are not expected to be strong enough to cause direct physical damage to organisms living on the reefs.

Possible impacts from routine activities of OCS oil and gas operations include anchoring, structure emplacement and removal, pipeline emplacement, drilling discharges, and discharges of produced waters. In addition, accidental subsea oil spills, or blowouts associated with OCS activities can cause damage to pinnacle communities. Long-term OCS activities are not expected to adversely impact the live-bottom environment because these impact-producing factors are restrained by the continued implementation of the lease stipulation and site-specific mitigations. The inclusion of the Live Bottom (Pinnacle Trend) Stipulation would preclude the occurrence of physical damage, the most potentially damaging of these activities. The impacts to the live bottoms are judged to be infrequent because of the small number of operations in the vicinity of pinnacles and the distance from the habitat. The impact to the live/hard-bottom resource as a whole is expected to be slight because of the projected lack of community-wide impacts.

Impacts from blowouts, pipeline emplacement, muds and cuttings discharges, other operational discharges, and structure removals should be minimized because of the proposed Live Bottom (Pinnacle Trend) Stipulation and the dilution of discharges and resuspended sediments in the area. Potential impacts from discharges would be further reduced by USEPA discharge regulations and permits restrictions.

The incremental contribution of the proposed action to the cumulative impact is expected to be slight, with possible impacts from physical disturbance of the bottom, discharges of drilling muds and cuttings, other OCS discharges, structure removals, and oil spills. Negative impacts should be restricted by the implementation of the Live Bottom (Pinnacle Trend) Stipulation, site-specific stipulations, the depths of the features, the currents in the live-bottom area, and the distance of pinnacle habitats from the source of impact.

4.1.1.6.2. Live Bottoms (Low Relief)

A new chapter describing live-bottom (low-relief) areas is included in this document. It is a summary of new information and the description of the biology of live-bottom (low relief) areas found in Chapter III.C.2 of *Gulf of Mexico OCS Oil and Gas Lease 181: Eastern Planning Area, Final Environmental Impact Statement* (Sale 181 EIS) (USDOI, MMS, 2001).

A fine-grained quartz sand sheet covers most of the Mississippi-Alabama shelf; however, numerous hard bottoms formed of sedimentary rock occur in the CPA off the Mississippi River Delta and seaward of the Chandeleur Islands (Schroeder, 2000). Low-relief, hard-bottom features are located on the inner and middle Mississippi-Alabama shelf. These features include isolated low-relief, reef-like structures; rubble fields; low-relief flat rocks (e.g., 6 m long and 60 cm thick; 20 ft long and 2 ft thick); limestone ledges (e.g., 4 m [13 ft] high); rocky outcrops off Mobile Bay (18- to 40-m [59- to 131-ft] depth range; 5 m wide and 2 m high; 16 ft wide and 7 ft high); and clustered reefs (e.g., tens of meters across and 3 m [10 ft] high) (Schroeder et al., 1988; Schroeder, 2000).

The Live Bottom (Low Relief) Stipulation implemented by BOEMRE protects biological resources of live-bottom areas from potential impacts by oil and gas activities to a depth of 100 m (328 ft) in the EPA and a small northeastern portion of the CPA. The Live Bottom (Low Relief) Stipulation defines low-relief areas as “seagrass communities, areas that contain biological assemblages consisting of sessile invertebrates living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where a hard substrate and vertical relief may favor the accumulation of turtles, fish, or other fauna” (USDOI, MMS, 2009b). Sessile invertebrates may include sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, or corals. The BOEMRE recommends the application of the Live Bottom (Low Relief) Stipulation for a proposed action within one of the OCS lease blocks that has low-relief features.

4.1.1.6.2.1. Description of the Affected Environment

Hard bottoms of various types are present in many locations of the Mississippi-Alabama Shelf and the West Florida Shelf **(Figure 4-9**). Sediments across the area east of the Mississippi River transition from the silt/clay of the delta to quartzose riverine sands of the eastern rivers, to the carbonate Florida platform characterized by carbonate sands and generally clear waters (east of De Soto Canyon). Hard-bottom features on the Mississippi-Alabama-Florida Shelf (MAFLA) typically provide reef habitat for tropical organisms, including sessile epifauna (soft corals, nonreef-building hard corals, sponges, bryozoans, crinoids) and fish; these areas are typically of low relief (<1 m; 3 ft) (Thompson et al., 1999).

Live-bottom communities are widely scattered across the West Florida Shelf (**Figure 4-9**). The shelf is a relatively flat table of carbonate (karst limestone geology) that is largely covered with carbonate sand sheets. In many places, the sand moves around due to seasonal storms, forming ephemeral (temporary) patches of sand interspersed with exposed hard bottom. Various species of sessile (attached) reef fauna and flora grow on the exposed hard grounds. Some species, such as sea whips and other gorgonians that are tall enough, often survive when sand moves in to cover the bottom again.

Some areas have enough relief to support permanent reefs. The Florida Middle Ground is probably the best known and most biologically developed of these areas on the West Florida Shelf, with extensive colonization by hermatypic (reef-building) corals and related communities. Several other reef areas are

present and have varying measures of protection including Pulley Ridge, Steamboat Lumps, Madison Swanson, and the Sticky Grounds (**Figure 4-9**).

Ecology of Inner- and Middle-Shelf Hard Bottoms of the Mississippi-Alabama Shelf

Nearshore hard-bottom areas are located on the Mississippi-Alabama shelf in 18-40 m (60-130 ft) of water (**Figure 4-9**). Inner- and middle-shelf features include rubble fields, low-relief flat rocks (e.g., 6 m long and 60 cm thick; 20 ft long and 2 ft thick), outcrops (e.g., 5 m wide and 2 m high; 16 ft wide and 7 ft high), limestone ledges (e.g., 4 m [13 ft] high), and clustered reefs (e.g., tens of meters across and 3 m [10 ft] high) (Schroeder, 2000). Four types of rock formations that form the hard-bottom areas are described by Schroeder et al. (1988).

- massive to nodular sideritic sandstones and mudstones, which are scattered on the central and western portions of the shelf;
- slabby-aragonite-cemented coquina and sandstone rubble associated with storm related ridges of shell and sand on the central shelf;
- dolomitic sandstone in small irregular outcrops; and
- calcite cemented algal calcirudite occurring in reef-like knobs on the southeastern shelf.

Schroeder et al. (1988 and 1989) described four live-bottom areas west of De Soto Canyon: Southeast Bank, Southwest Rock, Big Rock/Trysler Grounds, and features at the 17 Fathom Hole (**Figure 4-9**).

- The Southeast Bank is a rock rubble field site in 21-27 m (69-87 ft) of water-bearing encrusting epifauna (mostly the soft corals *Leptogorgia virgulata* and *Lophogorgia hebes*).
- The Southwest Rock area is in fact made of two rocks that are 10 m (33 ft) apart. The larger of the two is 7-9 m (23-30 ft) wide and 1-1.5 m (3-5 ft) high. The smaller rock is 1.5-3.5 m (5-11 ft) wide, but it is almost level with the surrounding rubble substrate.
- The Big Rock/Trysler Grounds are 5 m (16 ft) tall mound-like structures of rock rubble found in 30-35 m (98-115 ft) of water.
- The features at the 17 Fathom Hole are reef-like and mound-like. One reef-like feature was 100 m (328 ft) long, 35 m (115 ft) wide, and 2 m (7 ft) high. A mound-like feature was made of rock rubble, covered a 300 m^2 (3,228 ft^2) area, and rose 2 m (7 ft) above the seafloor.

The soft corals *Leptogorgia virgulata* and *Lophogorgia hebes* were the most frequently encountered encrusting organisms amongst inner- and mid-shelf hard bottoms. Other biotic cover, not as common as soft corals, was made of hydroids and bryozoans (Schroeder et al., 1988 and 1989). Brooks (1991) found shallow-water hard bottoms off Mobile Bay that support living algae communities. The 40-Fathom Isobath area is located 24 km (15 mi) northeast of the pinnacles area in water depths of approximately 75 m (245 ft). This area consists of topographic features with up to 9 m (30 ft) of relief that are either mound-like, pinnacle-like, or ridge-like in form (Schroeder et al., 1988 and 1989).

Head of De Soto Canyon

Shipp and Hopkins (1978) found a hard-bottom area of large, rectangular limestone blocks rising up to 10 m (33 ft) off the seafloor near the head of De Soto Canyon in 55 m (180 ft) of water (**Figures 4-9 and 4-10**). Live cover included sponges, nonreef-building hard coral (*Oculina diffusa*), soft corals (*Lophogorgia cardinalis* and *L. hebes*), and an antipatharian (*Antipathes* sp.). A diverse and abundant

tropical fish community was associated with the hard bottom. Benson et al. (1997) found another important hard bottom, the "De Soto Canyon rim feature," on the western edge of the canyon head.

Madison-Swanson Marine Reserve

The Madison-Swanson Marine Reserve is 65 km (40 mi) southwest off Cape San Blas, Florida, in waters 60-95 m (200-315 ft) deep (**Figure 4-4**). It covers approximately 300 km^2 (115 mi^2) and consists of relic reef formations. The reef has outcrops of 1- to 3-m (3- to 10-ft) relief with a ridge of 15-m (50-ft) relief and a series of pinnacles about 9 m (30 ft) high. It supports a deep reef community with sponges, sea fans, black corals, scattered *Oculina* corals, echinoderms, and crabs. It is protected as a grouper spawning site.

Steamboat Lumps Marine Reserve

The Steamboat Lumps Marine Reserve is 161 km (100 mi) south-southeast of Cape San Blas, Florida, in waters 70-100 m (230-330 ft) deep (**Figure 4-4**). It covers approximately 357 km^2 (138 mi^2) and consists of relic reef formations. The reserve has a series of five broad terraces pockmarked with depressions. It supports a deep reef community with sponges, sea fans, black corals, scattered *Oculina* corals, echinoderms, and crabs. It is protected as a grouper spawning site.

Florida Middle Ground

Amongst the most studied hard-bottom features of the West Florida Shelf in terms of live cover and relief are the outcroppings of the Florida Middle Ground. The crests of the Florida Middle Ground outcroppings support hard and soft corals, molluscs, crustaceans, echinoderms, sponges, polychaetes, algae, and fish (Hopkins et al., 1977). Jaap and Hallock (1991) found the Florida Middle Ground to be the most diverse habitat of the West Florida Shelf. The Florida Middle Ground is a series of outcroppings located 138 km (86 mi) south of Apalachee Bay and 150 km (93 mi) northwest of Tarpon Springs (**Figure 4-4**). They spread over a 35 km (21 mi) long and 11 km (7 mi) wide area, oriented north-south along its length. The outcroppings rise from a 40 m (131 ft) deep seafloor to within 23 m (75 ft) of the sea surface. The outcroppings are populated by tropical reef organisms, including live and dead corals, invertebrates, and fish (Grimm and Hopkins, 1977). More recent surveys of the Florida Middle Ground confirm continued health of the reef (ahermatypic corals, sponges, soft corals, and hydrozoans) (Mallinson et al., 1998 and 2006; Coleman et al., 2009).

Sticky Grounds

The Sticky Grounds is a trend of seafloor mounds about 185 km (115 mi) west of Tampa Bay, Florida (**Figure 4-4**). They occur in water depths of 120-130 m (390-425 ft). They are uniformly dispersed mounds of about 20 m (65 ft) in diameter with 10 m (33 ft) of relief. They are thought to be relic drowned reefs, similar to the Pinnacle Trend features (Locker, personal communication, 2008).

Pulley Ridge

The Pulley Ridge area consists of a series of submerged linear ridges likely representing the shoreline at the last sea level lowstand. Pulley Ridge is found in water depths of 60-110 m (200-360 ft) (Cash et al., 2010), trends in a north-south direction, and stretches approximately 300 km (200 mi) in the western part of the shelf off southwest Florida (**Figure 4-4**). It ranges about 5-15 km (3-9 mi) wide (Cash et al., 2010; Jaap and Halley, 2008) and typically has about 10 m (33 ft) of relief. The southern 30 km (18.75 mi) of the reef is colonized by a robust reef community dominated by hermatypic (reef-building) stony corals, coralline red algae, and green algae (Halley et al., 2004; Jarrett et al., 2002). The most common corals are the lettuce corals (*Leptoseris cucullata* and *Agaricia* spp.) (Jaap and Halley, 2008), and the reef exhibits 10-60 percent coral cover (Culter et al., 2005).

The bathymetry in the 70- to 90-m depth range is irregular, and numerous ledges, holes, and depressions are seen on the seafloor (CSA, 1988 and 1990). Where the coral reef is not prevalent, Pulley Ridge is capped by coralline algal growths (algal nodules and algal pavements), which provide additional

hard substrate for sessile epifauna even where the underlying rock is not exposed (CSA, 1990). Coralline algae appear to produce as much carbonate sediment as the stony corals; algal nodule and cobble zones are prevalent in deeper waters around much of the Ridge below 80 m (260 ft) (Halley et al., 2004).

Baseline Conditions following the *Deepwater Horizon* Event

The following sections contain all new data since the Multisale EIS and the 2009-2010 Supplemental EIS. Extensive literature, Internet, and database searches have been conducted for results of scientific data at pinnacle and low-relief, hard-bottom features following the DWH event. Although many research cruises have occurred, very few reports containing data have been released as of the publication of this Supplemental EIS. Descriptions of studies in progress are discussed, and any results indicated are included below. A few early data releases have indicated that baseline conditions near the well may have been changed from conditions described in the Multisale EIS and the 2009-2010 Supplemental EIS.

The DWH event may have been located close enough to some hard-bottom features on the Mississippi-Alabama shelf to cause impacts. A recent report documents damage to a deepwater coral community 7 mi (11 km) southwest of the blowout, in an area that oil plume models predict as the direction of travel for subsea oil plumes from the DWH event. Results are still pending, but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts (USDOI, BOEMRE, 2010j).

Larger pinnacle formations, the Alabama Alps (including the 36 Fathom Ridge) and Roughtongue Reef, were located beneath a portion of the surface oil plume during part of the DWH event (Boland et al., 2010). The Alabama Alps, 40 nmi (74 km; 46 mi) north of the well, was beneath the surface oil plume beginning April 29, 2010; the Roughtongue Reef, 100 nmi (185 km; 115 mi) northeast of the well, was beneath the plume beginning May 20, 2010 (Boland et al., 2010). They were still beneath the plume at the time of the writing of the Boland et al. (2010) document (July 2, 2010). These features will be studied to determine if they have been impacted similarly to the coral communities located closer to the well (Boland et al., 2010).

Water column hydrocarbon measurements collected during the DWH event suggest that it is unlikely that the pinnacle features were acutely affected by the oil or dispersed oil. Water samples collected by the R/V *Weatherbird* on May 23-26, 2010, located 40 nmi (74 km; 46 mi) and 45 nmi (83 km; 52 mi) northeast of the DWH rig revealed that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm (Haddad and Murawski, 2010). The total petroleum hydrocarbons concentrations 40 nmi (74 km; 46 mi) northeast of the well were 0.480 ppm and 0.114 ppm at 50-m (164 ft) and 100-m (328-ft) depth, respectively. The total petroleum hydrocarbons concentrations 45 nmi (83 km; 52 mi) northeast of the well were 0.174 ppm and 0.237 ppm at 50 m (164 ft) and 100 m (328 ft), respectively (Haddad and Murawski, 2010). The crests and bases of the Alabama Alps and Roughtongue Reef fall between these two water depths and are 40 nmi (74 km; 46 mi) north and 100 nmi (185 km; 115 mi) northeast of the well (Boland et al., 2010) (**Figures 4-7 and 4-8**). The measured total petroleum hydrocarbons in the water column near these features indicate the concentrations of total petroleum hydrocarbons that the hard-bottom features may have been exposed to were extremely low.

Concentrations of oil in the 1 ppm range, which is higher than those recorded near the pinnacles, but in the range of concentrations of dispersed oil reported from different sites in other studies (McAuliffe et al., 1981a; Lewis and Aurand, 1997) are likely to cause chronic or short-term impacts to corals, as opposed to acute toxicity (Dodge et al., 1984; Wyers et al., 1986; Kushmaro et al., 1997). Therefore, any impacts to coral 40 nmi (74 km; 46 mi) north and 100 nmi (185 km; 115 mi) northeast of the well would be sublethal and may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment (Kushmaro et al., 1997; Loya, 1975 and 1976a; Rinkevich and Loya, 1977).

Studies to Measure the Impact of the *Deepwater Horizon* Event

Many studies have been planned to analyze the impact of the DWH event and some have been carried out already, although not all of the results have been analyzed or published at the time of the writing of this Supplemental EIS. The long-lasting impacts of this event will take years to determine. Initial data included in this chapter only show the immediate impact, primarily on water quality; long-term effects are not known. As more studies are conducted and more data are released, we will have a better

understanding of the breadth of the effects of the DWH event. The following descriptions outline studies that will be conducted in the Pinnacle Trend area and low-relief, hard-bottom areas.

The NRDA has been approved to conduct an impact assessment to chemosynthetic, deepwater coral, and mesophotic coral (pinnacle) environments in the Gulf of Mexico as a result of the DWH event. Some pinnacle communities were beneath the surface plume of the oil spill for extended periods of time (Boland et al., 2010). The Alabama Alps, 40 nmi (74 km, 46 mi) north of the well, was beneath the surface oil plume beginning April 29, 2010; the Roughtongue Reef, 100 nmi (185 km; 115 mi) northeast of the well, was beneath the plume beginning May 20, 2010 (Boland et al., 2010). They were beneath the plume as of the release of the study (July 2, 2010). Studies at the pinnacles will include a comparison of new ROV video and digital imagery to previously collected images from prior studies and laboratory analysis of tissue and sediment for petroleum hydrocarbons (Boland et al., 2010). These data have yet to be published.

Florida Atlantic University, Harbor Branch Oceanographic Institute, has conducted a "Rapid Response to the *Deepwater Horizon* Oil Spill" exploration of the Florida Shelf Edge. Although data have not been published at the time of this document's release, the characterization of benthic and mid-water habitats was conducted from July 9 to August 7, 2010 (Pomponi, 2010). Mission objectives of the exploration included (1) benthic and mid-water habitat baseline and oil impact assessments, which targeted deepwater and shelf-edge reefs and hard-bottom essential fish habitat; (2) documenting oil and dispersant impacts on benthic and mid-water habitats and marine organisms; (3) documenting the location of any encountered submerged oil plumes; and (4) conducting education and outreach activities. The survey's primary focus was on the West Florida Shelf; however, additional sites off other Gulf Coast States may have been added as the route of the vessel was flexible dependent on the path of the oil plume. Areas considered for study included the mesophotic and shelf-edge reefs (30-200 m; 100-656 ft) including habitat areas of particular concern and marine sanctuaries off Texas, including the Flower Garden Banks National Marine Sanctuary, shelf-edge paleoshores along the Alabama Shelf (The Alps), West Florida Shelf (Madison-Swanson Marine Reserve, Twin Ridges, and Florida Middle Ground), and Southwest Florida Shelf (Pulley Ridge and Tortugas Ecological Reserve Preserve). Deepwater sites (>200 m; 656 ft) that were studied included *Lophelia* coral habitat (Viosca Knoll, Mississippi Canyon, and De Soto Canyon) and the West Florida Shelf lithotherms (500 m; 1,640 ft) (Pomponi, 2010).

The NOAA R/V *Seward Johnson* conducted a baseline survey of the water column and seafloor in areas of the GOM from which the data will be used to measure changes if oil from the DWH event reaches the areas investigated (USDOC, NOAA, 2010g). Submersibles and ROV's were used to observe baseline conditions of coral reefs and benthic organisms along the deep reef and hard-bottom regions of the east, south, and west Florida shelf and slope. The research cruise followed a path from the *Oculina* reefs off southeast Florida, through the Straits of Florida to the Dry Tortugas, north through the eastern and northern GOM, and west along the Florida shelf and slope toward Alabama and Mississippi (USDOC, NOAA, 2010g).

The limited data currently available on the impacts of the DWH event make it difficult to definitively say if any impacts have occurred or may occur to the Pinnacle Trend and low-relief, hard-bottom features in the CPA. It appears some impacts have occurred to deepwater corals within 7 mi (11 km) of the well, although definitive testing of samples is necessary. Oil dispersed near the source in 1,500 m (4,921 ft) of water depth formed underwater plumes that affected some deep-sea environments. However, that oil is carried by deepwater currents, which do not transit up onto the continental shelf (Pond and Pickard, 1983).

Once more data are released, we will have a better understanding of the measured impacts and possible long-term effects of this event.

4.1.1.6.2.2. Impacts of Routine Events

Background/Introduction

The Live Bottom (Low Relief) Stipulation protection covers lease blocks that include waters less than 100 m (328 ft) in the EPA and a portion of the northeastern CPA that was previously part of the EPA (**Figure 4-4**). Blocks subject to the Live Bottom (Low Relief) Stipulation, including those in the CPA, are not included in the area to be offered in the CPA proposed action. No lease sales since the 1980's have included blocks in areas where this stipulation applies. However, CPA blocks adjacent to this area

are included in the CPA proposed action. The proposed Live Bottom (Low Relief) Stipulation is described in NTL 2009-G39 (USDOI, MMS, 2009b). The BOEMRE recommends the implementation of the Live Bottom (Low Relief) Stipulation for a proposed action within one of the OCS lease blocks that has low-relief features. The stipulation is designed to prevent drilling activities and anchor emplacement (the major potential impacting factors on these live bottoms resulting from offshore oil and gas activities) from damaging the low-relief features. Both exploration and development plans will be reviewed on a case-by-case basis to determine whether a proposed operation could impact a low-relief area. If it is determined from site-specific information derived from BOEMRE studies, published information from other research programs, geohazards survey information, or another source that the operation would impact a low-relief area, the operator may be required to relocate the proposed operation.

Since the blocks covered by the Live Bottom (Low Relief) Stipulation are outside the area to be offered in the CPA proposed action, only those blocks adjacent to the CPA proposed action in the northeastern portion of the CPA could be affected by routine impacts (**Figure 4-4** of this Supplemental EIS and Figure 2-1 of the 2009-2012 Supplemental EIS). The impact analysis presented below is for routine activities associated with the CPA proposed action.

A number of OCS-related factors may cause adverse impacts on the live-bottom communities and features. Damage caused by anchoring, infrastructure and pipeline emplacement, infrastructure removal, blowouts, drilling discharges, produced-water discharges, and oil spills can cause mortality of live-bottom organisms or the alteration of sediments to the point that recolonization of the affected areas may be delayed or impossible. Impacts from oil spills and blowouts are discussed in **Chapter 4.1.1.6.2.3**.

Construction Impacts on Low-Relief Features

Anchoring may damage lush biological communities or the structure of the live-bottom features themselves, which attract fish and other mobile marine organisms. Anchor damage from support boats and ships, floating drilling units, and pipeline-laying vessels greatly disturb areas of the seafloor and are the greatest threats to live-bottom areas at these depths. The size of the affected area would depend on water depth, anchor and chain sizes, chain length, method of placement, wind, and current. Anchor damage may result in the crushing and breaking of hard bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary species (cup corals, octocorals, and hydrocorals), may recolonize areas more rapidly than slow-growing colonial forms that disperse larval great distances (Lissner et al., 1991). Such anchoring damage, however, should be minimized on low-relief hard bottoms, as no bottom-disturbing activities are permitted on the live-bottom habitat. Such damage would only be possible if construction activities take place immediately adjacent to designated live-bottom (low-relief) blocks.

The emplacement of infrastructure, including drilling rigs and platforms, on the seafloor would crush the organisms directly beneath the legs or mat used to support the structure. Pipeline emplacement directly affects the benthic communities through burial and disruption of the benthos and through resuspension of sediments. These resuspended sediments may obstruct filter-feeding mechanisms and gills of fishes and sedentary invertebrates. The areas affected by the placement of the platforms and rigs are predominantly soft-bottom regions where the infaunal and epifaunal communities are not as unique as the hard-bottom communities.

Infrastructure emplacement and pipeline emplacement could result in suspended sediment plumes and sediment deposition on the seafloor. Considering the relatively elevated amounts of drilling muds and cuttings discharged per well (approximately 2,000 metric tons [2,205 tons] for exploratory wells—900 metric tons [992 tons] of drilling fluid and 1,100 metric tons [1,213 tons] of cuttings—and slightly lower discharges for development wells) (Neff, 2005), potential impacts on biological resources of hard-bottom features should be expressly considered if drill sites occur in blocks adjacent to such features. Potential impacts could be incurred through increased water-column turbidity, the smothering of sessile benthic invertebrates, and local accumulations of contaminants.

Differences in the dispersal patterns for well cuttings and drilling muds result from differences in disposal methodology (surface disposal or bottom shunting). For example, well cuttings that are disposed of at the water's surface tend to disperse in the water column and are distributed widely over a large area at low concentrations (CSA, 2004b; NRC, 1983). On the other hand, cuttings that are shunted to the seafloor are concentrated over a smaller area in piles instead of being physically dispersed over wide areas (Neff, 2005). The heaviest concentrations of well cuttings and drilling fluids, for both water-based and synthetic-based drilling muds, have been reported within 100 m (328 ft) of wells and are shown to decrease beyond that distance (CSA, 2004b; Kennicutt et al., 1996). They are usually distributed unevenly and in patches, often dependent on prevailing currents (CSA, 2004b). A gradient of deposition may reach up to 500 m (1,640 ft) from the well, depending on surrounding environmental conditions (Kennicutt et al., 1996).

Although the Live Bottom (Low Relief) Stipulation requires that low-relief features be protected from impact, some cuttings may reach the live-bottom features. Surface-released cuttings rarely accumulate thicknesses of about 1 m (3 ft) immediately adjacent to the well; thicknesses are usually not higher than a few tens of centimeters (about 1 ft) in the GOM. A gradient that encompasses most of the cuttings settles within 100 m (328 ft) of the well site. Cuttings settle in a patchy distribution determined by water currents and limited to about 250 m (820 ft) from the well site (CSA, 2004b). The source of cuttings released at the surface would be, at the closest, in blocks adjacent to live-bottom (low-relief) habitats. However, low-relief features could react negatively to drill cuttings if they do contact the habitat. For example, the ahermatypic (nonreef-building) coral, *Caryophyllia* sp., which may be found on some of these hard-bottom habitats, has displayed a significant dose-response relationship with sediment loading where densities of the species decreased with an increase in drilling mud particles (Hyland et al., 1994).

In order to protect live-bottom features, relocation of operations to avoid live-bottom areas, shunting drilling fluids and cuttings to avoid live-bottom areas, transportation of drilling fluids and cuttings to approved disposal sites, and/or site monitoring may be required. These measures would limit or prevent well drilling activities from occurring in sensitive live-bottom areas. If bottom shunting of cuttings is used to protect features, the live-bottom areas, including those of low relief, would be protected from burial. Also, the USEPA general NPDES permit sets special restrictions on discharge rates for muds and cuttings to protect biological features. Chapters 4.1.1.4.1 and 4.2.1.1.2.2 of the Multisale EIS detail the NPDES permit's general restrictions and the impacts of drilling muds and cuttings on marine water quality and seafloor sediments. If cuttings and drilling fluids are transported to approved disposal sites, the live bottoms would be even further protected from sedimentation. Due to the Live Bottom (Low Relief) Stipulation and USEPA discharge regulations, turbidity and smothering impacts of sessile invertebrates on hard-bottom features caused by drilling muds and cuttings are anticipated to be minimized.

Drilling fluid adhering to cuttings forms plumes that are rapidly dispersed on the OCS. Approximately 90 percent of the material discharged (cuttings and drilling fluid) settle rapidly to the seafloor, while 10 percent forms a plume of fine mud that drifts in the water column (Neff, 2005). Although drilling mud plumes may be visible 1 km (0.6 mi) from the discharge, rapid dilution of drilling mud plumes was reported within 6 m (20 ft) from the release point (Shinn et al., 1980; Hudson et al., 1982). Drilling muds and cuttings may be diluted 100 times at a distance of 10 m (33 ft) from the discharge and 1,000 times at a distance of 100 m (328 ft) from the discharge (Neff, 2005). Dilution continues with distance from the discharge point, and at 96 m (315 ft) from the release point, a plume was measured only a few milligrams/liter above background suspended sediment concentrations (Shinn et al., 1980). Suspended sediment concentrations 6 m (20 ft) from the discharge are often less than those produced during storms or from boat wakes (Shinn et al., 1980). With consideration that drilling is not allowed on live-bottom habitats, that protective measures must be taken to avoid low-relief features, and that field measurements of suspended solids rapidly decline with distance from the source, turbidity impacts to live-bottom communities should be minimized.

There is little opportunity for drilling muds and cuttings to affect low-relief live bottoms. The low-relief, live-bottom habitats are mostly in the EPA, with some stretching westward into the edge of the CPA. Since the northeast portion of the CPA is not included in the area to be offered in the CPA proposed action, only activities on the northeast border of the CPA proposed action would be adjacent to some low-relief, live-bottom habitats. The Mississippi River flows into this area of the GOM, resulting in high levels of natural turbidity. This turbidity forms a gradient from the source with levels declining

farther from the source. So, while muds and cuttings from the CPA proposed action could drift to the east, they will decline to background levels before reaching sensitive live-bottom habitats. The organisms in this area are tolerant of turbid environments (Rogers, 1990; Gittings et al., 1992a) and should not be impacted by the residual suspended sediment discharged during the drilling of a well. Many of the organisms that predominate in these communities also grow tall enough to withstand the sedimentation that results from their typical turbid environment or they have flexible structures that enable the passive removal of sediments (Gittings et al., 1992a). Any mud that may reach these organisms can be removed by tentacle motion and mucus secretion (Shinn et al., 1980; Hudson and Robbin, 1980).

Recruitment studies conducted by Continental Shelf Associates (CSA) and Texas A&M University, Geochemical and Environmental Research Group (GERG); Marine Resources Research Institute (MRRI); and others suggest that recovery of hard-bottom communities following a disturbance will be slow (CSA and GERG, 2001; MRRI, 1984; Montagna and Holmberg, 2000). Epibiont recruitment showed relatively slow development of fouling community constituents on recruitment plates. Early colonizers are opportunistic epifauna, such as hydroids, bryozoans, barnacles, and bivalves that are tolerant of sediment loading (CSA and GERG, 2001; MRRI, 1984). Basically, only the earliest successional stages were observed after 1 year (MRRI, 1984) and after 27 months of exposure (CSA and GERG, 2001), and the epibiota typically associated with nearby hard-bottom features were rare on the plates (CSA and GERG, 2001). No sponges or corals had settled after 1 year (MRRI, 1984). Corals and sponges are known to display delayed recruitment and slow growth, and after 10 years corals and anemones were sparse on artificial reef habitats, and the community had still not reached “climax” state (MRRI, 1984).

It is not known whether the results of the recruitment studies would have differed if the substrate had consisted of exposed patches of natural hard bottom; however, because analysis of artificial reefs exposed for months to several years also indicates slow community development, it can be anticipated that hard-bottom communities take a long time to recruit and develop (MRRI, 1984). Although settling plates and artificial reefs may differ from natural reefs, they can help to indicate recruitment time in a defaunated area (MRRI, 1984).

Long-Term and Operational Impacts on Low-Relief Features

Drilling operations may impact live-bottom communities. Drilling operations in Puerto Rico have led to reduced coral cover out to 65 m (213 ft) from the well, probably as a result of cutting deposition (Hudson et al., 1982). Corals beyond this distance did not show reduced surface cover (Hudson et al., 1982). Live bottoms of low-relief features may experience some deposition of cuttings, especially if a well is within a few hundred meters of a live bottom. Impacts as a result of cuttings disposal may reach 100-200 m (328-656 ft) from a well (Montagna and Harper, 1996; Kennicutt et al., 1996). The proposed Live Bottom (Pinnacle Trend) Stipulation requires all bottom-disturbing activity to avoid direct contact with live-bottom habitat. Wells drilled near low-relief, live-bottom features may be required to shunt cuttings to within 10 m (33 ft) of the seafloor. Bottom shunting would help protect the live-bottom features because it results in localized deposition of cuttings at a depth that is often greater than the biological activity of the live bottoms or in an area that avoids the live bottoms. Further protection may be implemented if the cuttings and drilling fluids are transported to an approved disposal site. The implementation of the Live Bottom (Low Relief) Stipulation is anticipated to reduce exposure pathways of drilling activities to benthic organisms on live bottoms, eliminating long-term operational impacts, such as exposure to turbidity and sedimentation or associated contaminants.

Impacts as a result of exposure to contaminants may occur to live-bottom organisms within 100-200 m (328-656 ft) of the well as a result of offshore oil and gas production (Montagna and Harper, 1996; Kennicutt et al., 1996; Hart et al., 1989; Kennicutt, 1995; CSA, 2004b). Sand content, metals, barium, inorganic carbon, and petroleum products have all been reported to be elevated near platforms (Kennicutt, 1995). Distribution of discharges tends to be patchy, have sharp gradients, and be directional (Kennicutt, 1995). The greatest impacts occur in low-energy environments where depositions may accumulate and not be redistributed (Neff, 2005; Kennicutt et al., 1996).

Elevated levels of barium, silver, cadmium, mercury, lead, and zinc were found out to 200 m (656 ft) from platforms and are likely a product of drilling muds and cuttings (Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). Metal concentrations in sediments near gas platforms (approximately out to 100 m [328 ft]) have been reported above those that may cause deleterious

biological effects. The impacts are believed to be a result of metal toxicity originating from drill cuttings during the installation of the well, which remain in the sediment (Montagna and Harper, 1996; Carr et al., 1996). Hydrocarbon enrichment has been reported within 25 m (80 ft) and out to 200 m (656 ft) of petroleum platforms, and the concentrations decreased with distance from the platforms (Hart et al., 1989; Chapman et al., 1991; Kennicutt, 1995; Kennicutt et al., 1996). The concentrations of PAH's in the sediment surrounding platforms, however, were below the biological thresholds for marine organisms and appeared to have little effect on benthic organisms (Hart et al., 1989; McDonald et al., 1996; Kennicutt et al., 1996). If any of the drill cuttings reach live-bottom features, impacts from metal or hydrocarbon exposure may occur. Although the literature does not report the impacts to gorgonians or soft corals as a result of exposure to contaminants in cuttings, infauna have shown effects including reduced fecundity, altered populations, and acute toxicity (Montagna and Harper, 1996; Carr et al., 1996; Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). Impacts to benthos would be reduced with distance from the discharge.

Produced waters are discharged at the water surface throughout the lifetime of the production platform and may contain hydrocarbons, trace metals, elemental sulfur, and radionuclides (Kendall and Rainey, 1991). Heavy metals enriched in the produced waters include cadmium, lead, iron, and barium (Trefry et al., 1995). Produced waters may impact both organisms attached to the production platform and benthic organisms beneath the platform. A detailed description of the impacts of produced waters on water quality and seafloor sediments is presented in Chapter 4.2.1.1.2 of the Multisale EIS.

Information is contradictory on the distance from a platform that produced waters can affect benthic communities. Impacts have been reported from 100 m (328 ft) of the source to 1 km (0.6 mi) from the source (Peterson et al., 1996; Armstrong et al., 1977; Osenberg et al., 1992). The produced waters, however, are rapidly diluted and impacts are generally only observed within proximity of the discharge point (Gittings et al., 1992b). Literature indicates that acute toxicity that may result from produced waters occurs "within the immediate mixing zone around a production platform" (Holdway, 2002). Past evaluation of the bioaccumulation of offshore produced-water discharges conducted by the Offshore Operators Committee (Ray, 1998) assessed that metals discharged in produced water would, at worst, affect living organisms found in the immediate vicinity of the discharge, particularly those attached to the submerged portion of platforms. Possibly toxic concentrations of produced water were reported 20 m (66 ft) from the discharge in both the sediment and the water column where elevated levels of hydrocarbons, lead, and barium occurred, but no impacts to marine organisms or sediment contamination were reported beyond 100 m (328 ft) of the discharge (Neff and Sauer, 1991; Trefry et al., 1995). Chronic exposure to produced waters may result in altered benthic communities favoring opportunistic species, altered species behavior, reduced growth, and decreased fecundity (Holdway, 2002).

Naturally occurring radioactive material in produced water was not found to bioaccumulate in marine animals (2 species of mollusks and 5 species of fish) (Ray, 1998). Because high-molecular PAH's are usually in such dilute concentrations in produced water, they pose little threat to marine organisms and their constituents, and they were not anticipated to biomagnify in marine food webs. Monocyclic hydrocarbons and other miscellaneous organic chemicals are known to be moderately toxic, but they do not bioaccumulate to high concentrations in marine organisms and are not known to pose a risk to their consumers (Ray, 1998).

Produced waters may have some impact on live-bottom features, but the Live Bottom (Low Relief) Stipulation should help to reduce these impacts. The greatest impacts are reported adjacent to the discharge and out to 20 m (66 ft) from the discharge, but they are substantially reduced less than 100 m (328 ft) from the discharge. Because only a few potential live-bottom (low-relief) areas are adjacent to the area to be offered in the CPA proposed action, produced waters are not expected to reach the sensitive habitats in concentrations that would produce negative effects. The distance between the habitat and the discharge would allow for dispersion of the produced waters, reducing the concentration of discharged material to which the live bottoms may be exposed. The USEPA general NPDES permit restrictions on the discharge of produced water would also limit the impacts on biological resources of live bottoms.

Structure-Removal Impacts on Low-Relief Features

The impacts of structure removal on live-bottom benthic communities can include turbidity, sediment deposition, explosive shock-wave impacts, and scouring from trawling to retrieve debris. Both explosive

and nonexplosive removal operations would disturb the seafloor by generating considerable turbidity. Suspended sediment may evoke physiological impacts in benthic organisms including "changes in respiration rate, . . . abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus" (Anchor Environmental CA, L.P., 2003). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Sediment deposition that occurs in ahermatypic coral communities may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced coverage, changes in species diversity and dominance patterns, alterations in growth rates and forms, decreased calcification, increased production of mucus, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Octocorals and gorgonians are more tolerant of sediment deposition than scleractinian corals, as they grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a). Gorgonians, corals, and sponges on low-relief features have also been reported to protrude above accumulated sediment layers, and it is hypothesized that these organisms can resist burial by growing faster than the sediment accumulates over the hard substrate upon which they settle (Lissner et al., 1991).

The shock waves produced by explosive structure removals may also harm benthic biota. However, corals and other sessile invertebrates have a high resistance to shock. O'Keeffe and Young (1984) described the impacts of underwater explosions on various forms of sea life using, for the most part, open-water explosions much larger than those used in typical structure-removal operations. They found that sessile benthic organisms, such as barnacles and oysters, and many motile forms of life, such as shrimp and crabs, that do not possess swim bladders were remarkably resistant to shock waves generated by underwater explosions. Oysters located 8 m (26 ft) away from the detonation of 135-kg (298-lb) charges in open water incurred a 5 percent mortality rate. Crabs distanced 8 m (26 ft) away from the explosion of 14-kg (31-lb) charges in open water had a 90 percent mortality rate. Few crabs died when the charges were detonated 46 m (151 ft) away. O'Keeffe and Young (1984) also noted ". . . no damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods."

Benthic organisms appear to be further protected from the impacts of subbottom explosive detonations by rapid attenuations of the underwater shock wave traversing the seabed away from the structure being removed. The shock wave is significantly attenuated when explosives are buried, as opposed to detonation in the water column (Baxter et al., 1982). Theoretical predictions suggest that the shock waves of explosives set 5 m (15 ft) below the seabed, as required by BOEMRE regulations, would further attenuate blast effects (Wright and Hopky, 1998).

Charges used in OCS structure removals are typically much smaller than some of those cited by O'Keeffe and Young. The *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (USDOI, MMS, 2005) predicts low impacts on the sensitive offshore habitats from platform removal precisely because of the effectiveness of the proposed stipulation in preventing platform emplacement in the most sensitive areas of the GOM. Impacts on the biotic communities, other than those on or directly associated with the platform, would be limited by the relatively small size of individual charges (normally 50 lb [27 kg] or less per well piling and per conductor jacket) and by the fact that charges are detonated 5 m (15 ft) below the mudline and at least 0.9 seconds apart (timing needed to prevent shock waves from becoming additive) (USDOI, MMS, 2005). Also, because the live-bottom (low-relief) areas are generally far from the CPA proposed action, adverse effects to live-bottom features should be prevented.

Infrastructure or pipeline removal would impact the communities that have colonized the structures, many of which may also be found on live-bottom features. Removal of the structure itself would result in the removal of the hard substrate and the associated encrusting community. The overall community would experience a reduction in species diversity (both epifaunal encrusting organisms and the fish and large invertebrates that fed on them) with the removal of the structure (Schroeder and Love, 2004). The

epifaunal organisms attached to the platform would die once the platform is removed. However, the seafloor habitat would return to the original soft-bottom substrate that existed before the well was drilled.

Some structures may be converted to artificial reefs. If the rig stays in place, the hard substrate and encrusting communities would remain part of the benthic habitat. The diversity of the community would not change and associated finfish species would continue to graze on the encrusting organisms. The community would remain an active artificial reef. However, plugging of wells and other reef-in-place decommissioning activities would still impact benthic communities as discussed above, since all the steps for removal except final removal from the water would still occur.

Proposed Action Analysis

The Live Bottom (Low Relief) Stipulation covers lease blocks that include waters less than 100 m (328 ft) in the EPA and a northeastern portion of the CPA that was previously part of the EPA (**Figure 4-4**). Blocks subject to the Live Bottom (Low Relief) Stipulation, including those in the CPA, are not included in the area to be offered in the CPA proposed action. No lease sales since the 1980's have included blocks in areas where this stipulation applies. However, adjacent blocks in the CPA are included in the area to be offered in the CPA proposed action. For the CPA proposed action, 17-23 exploration/delineation wells, 62-85 development wells, and 20-25 production structures are projected for offshore Subareas C0-60. There are 9-14 exploration/ wells, 23-33 development wells, and 2-3 production structures projected for offshore Subareas C60-200. Few, if any, of the wells or production structures would be located near live-bottom (low-relief) areas because the areas are not included in the area to be offered in the CPA proposed action. Low-relief features would incur few incidences of anchor damage from support vessels for the same reason. Thus, anchoring events are not expected to impact the resource. Accidental anchor impacts, however, could occur, with recovery taking a few to many years, depending on the severity (Fucik et al., 1984; Rogers and Garrison, 2001; Lissner et al., 1991).

Pipeline emplacement also has the potential to cause considerable disruption to the bottom sediments in the vicinity of the live bottoms (Chapter 4.1.1.8.1 of the Multisale EIS); however, the implementation of the proposed Live Bottom (Low Relief) Stipulation, or a similar protective measure, would restrict pipeline-laying activities as well as oil and gas activities in the vicinity of the low-relief communities. The actual effect of pipeline-laying activities on the biota of the low-relief communities would be restricted to the resuspension of sediments. Burial of pipelines is only required in water depths of 60 m (200 ft) or less. Therefore, only the shallowest live-bottom communities would be affected by the increased turbidity associated with pipeline burial. The laying of pipeline without burial produces much less resuspension of sediments. The enforcement of the Live Bottom (Low Relief) Stipulation would help to minimize the impacts of pipeline-laying activities.

Summary and Conclusion

Oil and gas operations discharge drilling muds and cuttings that generate turbidity, potentially smothering benthos near the drill sites. Deposition of drilling muds and cuttings near low-relief areas would not greatly impact the biota of the live bottoms because the biota surrounding the low-relief features in or near the CPA are adapted to turbid (nepheloid) conditions and high sedimentation rates associated with the outflow of the Mississippi River (Gittings et al., 1992a). Regional surface currents and water depth would largely dilute any effluent. Additional deposition and turbidity caused by a nearby well are not expected to adversely affect the low-relief environment because such fluids would be dispersed upon discharge. Mud contaminants measured in the region reached background levels within 1,500 m (4,900 ft) of the discharge point (Shinn et al., 1993). Toxic impacts on benthos are limited to within 100-200 m (328-656 ft) of a well (Montagna and Harper, 1996; Kennicutt et al., 1996), and NPDES permit requirements limit discharge. The drilling of a well, therefore, would have localized impacts on the benthos near the well, which should be located away from live-bottom features according to the drilling stipulations.

The toxicity of produced waters has the potential to adversely impact the live-bottom organisms; however, as previously stated, many of the low-relief areas are not in the area to be offered in the CPA proposed action and the proposed Live Bottom (Low Relief) Stipulation would prevent the placement of oil and gas facilities upon (and consequently would prevent the discharge of produced water directly over) low-relief, live-bottom habitats.

Platform removals have the potential to impact nearby habitats. As previously discussed, the platforms would not be constructed directly on low-relief areas because these areas are either not included in the area to be offered in the CPA proposed action or are protected by the Live Bottom (Low Relief) Stipulation, distancing blasts from sensitive low-relief habitats. Benthic organisms on live bottoms should also have limited impact because they are resistant to blasts, tolerant of turbidity, can physically remove some suspended sediment, and may be located above or be tall enough to withstand limited sediment deposition. The implementation of the Live Bottom (Low Relief) Stipulation would help to prevent smothering events. Since the live-bottom areas are either not included in the area to be offered in the CPA proposed action or are protected by the Live Bottom (Low Relief) Stipulation, most of the potential impacts on live bottoms from bottom-disturbing activities (structure emplacement and removal) and operational discharges associated with the CPA proposed action would be prevented. Any contaminants that reach live-bottom features would be diluted from their original concentration; therefore, impacts that do occur should be sublethal.

Effects of the Proposed Action without the Proposed Stipulation

Activities resulting from the CPA proposed action without the exclusion of live-bottom (low-relief) habitats from the CPA proposed action and the protection of the Live Bottom (Low Relief) Stipulation could have an extremely deleterious impact on portions of the low-relief areas. Mechanical damage from anchoring, drilling operations, and other installation activities is potentially the most damaging impact because these activities could destroy biological communities or damage the structure of the low-relief areas themselves. This may in turn reduce the habitat or shelter areas occupied by commercial and recreational fishes. Those areas actually subjected to mechanical disruption would be severely impacted. Potential impacts on the low-relief, live-bottom areas from other impact-producing factors associated with OCS activities (pipeline emplacement, discharges of muds and cuttings, and explosive structure removals) would damage live-bottom areas, particularly by smothering organisms with heavy layers of drilling muds and cuttings.

4.1.1.6.2.3. Impacts of Accidental Events

Background/Introduction

The live-bottom (low-relief) features of the CPA sustaining sensitive offshore habitats are described in **Chapter 4.1.1.6.2.1**. Disturbances resulting from the CPA proposed action, including oil spills, blowouts, and chemical spills have the potential to disrupt and alter the environmental, commercial, recreational, and aesthetic values of live-bottom features of the CPA. Live bottoms (low relief) are defined in NTL 2009-G39, which describes the applicable lease stipulation effective on blocks in the EPA and several blocks in the northeast portion of the CPA (USDOI, MMS, 2009b). Note that none of those blocks are included in the area to be offered in the CPA proposed action. Therefore, oil and gas activities from this action do not coincide with the live-bottom (low-relief) habitats. Some areas leased as a result of the CPA proposed action could be adjacent to the sensitive habitats at the extreme western edge of the habitat range.

A search was conducted for additional new information published since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. Various Internet sources and journal articles were examined to discover any recent information regarding impacts of oil on benthic organisms. Sources investigated include literature published in journals and websites (NOAA, USEPA, and coastal universities). This is a new chapter describing accidental impacts to live-bottom (low-relief) areas. It is a summary of new information and the description of impacts to live bottoms (low relief) found in Chapter IV.D.1.a.(2)(a) of the Sale 181 EIS (USDOI, MMS, 2001b).

Possible Modes of Exposure

Oil released to the environment as a result of an accidental event may impact live-bottom features in several ways. Oil may be physically mixed into the water column from the sea surface, be injected below the sea surface and travel with currents, be dispersed in the water column, or be sedimented to particles

and sink to the seafloor. These scenarios and their possible impacts are discussed in the following sections.

An oil spill that occurs at the sea surface would result in a majority of the oil remaining at the sea surface. Lighter compounds in the oil would evaporate and some components of the oil may dissolve in the seawater. Evaporation removes the most toxic components of the oil, while dissolution may allow bioavailability of hydrocarbons to marine organisms for a brief period of time (Lewis and Aurand, 1997). The oil may also emulsify with water or sediment to particles and fall to the seafloor.

A spill that occurs below the sea surface (at the rig, along the riser between the seafloor and sea surface, or through leak paths on the BOP/wellhead) would result in only a portion of the released oil rising to the sea surface. If the leak is deep in the water column and the oil is ejected under pressure, oil droplets may become entrained deep in the water column (Boehm and Fiest, 1982). The upward movement of the oil may be reduced if methane in the oil is dissolved into the water column at high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). Large oil droplets will rise to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume or the injection of dispersants, may remain neutrally buoyant in the water column, creating a subsurface plume (Adcroft et al., 2010). Oil droplets less than 100 μm (0.004 in) in diameter may remain in the water column for several months (Joint Analysis Group, 2010a).

Impacts that may occur to benthic communities on live-bottom features as a result of a spill would depend on the type of spill, distance from the spill, relief of the biological feature, and surrounding physical characteristics of the environment (e.g., turbidity). The Live Bottom (Low Relief) Stipulation (appended to NTL 2009-G39) does not specify a buffer zone around low-relief, hard-bottom features, but it recommends that no bottom-disturbing activity occur near low-relief features that may impact the features, which results in drilling activities occurring away from low-relief, live-bottom features. This Agency has created the stipulation in order to protect hard-bottom habitats from disruption due to oil and gas activities. However, oil released during accidental events may reach live-bottom features. As described above, a portion of the oil released from a spill would rise to the sea surface, therefore, reducing impact to benthic communities by direct oil exposure. However, small droplets of oil that are entrained in the water column for extended periods of time may migrate onto live-bottom habitat. Although these small oil droplets will not sink themselves, they may also attach to suspended particles in the water column and then be deposited on the seafloor (McAuliffe et al., 1975). Exposure to subsea plumes, dispersed oil, or sedimented oil may result in long-term impacts such as reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. These impacts are discussed in the following sections.

Surface Slicks and Physical Mixing

Surface oil slicks can spread over a large area; however, the majority of the slick is comprised of a very thin surface layer of oil moved by winds and currents (Lewis and Aurand, 1997). Oil spills have the potential to foul benthic communities and cause lethal or sublethal effects to organisms that the oil contacts as it is moved over the sea surface. Low-relief, hard-bottom features may rise up to 4 m (13 ft) from the seafloor (Schroeder et al., 1988; Schroeder, 2000). Live-bottom features more than 10 m (33 ft) below the sea surface would be protected from contact with oil from surface slicks (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002).

Field data collected at the Atlantic entrance to the Panama Canal 2 months after a tanker spill has shown that subtidal coral did not show measurable impacts to the oil spill, presumably because the coral was far enough below the surface oil and the oil did not contact the coral (Rützler and Sterrer, 1970). A similar result was reported from a Florida coral reef immediately following and 6 months after a tanker discharged oil nearby (Chan, 1977). The lack of acute toxicity was again attributed to the fact that the corals were completely submerged at the time of the spill and that calm conditions prevented the oil from mixing into the water column (Chan, 1977).

Disturbance of the sea surface by storms can mix surface oil into the water column, but the effects are generally limited to the upper 10-20 m (33-66 ft) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Therefore, the depth of offshore live-bottom features below the sea surface should protect them from physical mixing of surface oil below the sea surface. Features in water depths shallower than 10 m (33 ft) would be more susceptible to oil impacts. However, low-relief live bottoms

nearshore are far from potential activities of the CPA proposed action. If dispersants are used, they would enable oil to mix into the water column and possibly impact organisms on the live-bottom features adjacent to the CPA proposed action. Dispersants are discussed later in this section.

Subsurface Plumes

A subsurface oil spill or plume could reach a live-bottom feature and would have the potential to damage the local biota contacted by oil. Such impacts on the biota may have severe and long-lasting consequences, including loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success.

Although no buffer zone is established for low-relief features, they are protected from bottom-disturbing activity, which in turn results in petroleum-producing activities occurring away from low-relief features. In addition, live-bottom, low-relief lease areas are excluded from the CPA proposed action. The distancing of petroleum-producing activities from live-bottom features allows for several physical and biological changes to occur to the oil before it reaches sensitive benthic organisms. Oil becomes diluted as it physically mixes with the surrounding water. The longer and farther a subsea plume travels in the sea, the more dilute the oil will be (Vandermeulen, 1982; Tkalich and Chan, 2002). In addition, microbial degradation of the oil occurs in the water column, reducing toxicity (Hazen et al., 2010; McAuliffe et al., 1981b). Subsea oil plumes transported by currents may not travel nearly as far as surface oil slicks because some oil droplets may conglomerate and rise or may be blocked by fronts, as was observed in the southern Gulf of Mexico during the *Ixtoc* spill (Boehm and Fiest, 1982). Should any of the oil come in contact with adult sessile biota, effects would be primarily sublethal, as the oil may be diluted by physical and biological processes by the time it reaches the features. Some low-level exposure impacts may be chronic, while others may be temporary, and some may not even be able to be measured over time.

Although the Live Bottom (Low Relief) Stipulation protects benthic organisms from petroleum-producing activity, it is possible that low levels of oil transported in subsea plumes may reach benthic features. Several studies have reported results for oil impacts on both hermatypic (reef-building) and ahermatypic (nonreef-building) corals. Although not all of the same species studied are present on low-relief, hard-bottom features, impacts are expected to be similar. For example, coral feeding activity may be reduced if it is exposed to low levels of oil. Experiments indicated that normal feeding activity of *Porites porites* and *Madracis asperula* were reduced when exposed to 50 ppm oil (Lewis, 1971). Tentacle pulsation of an octocoral, *Heteroxenia fuscescens*, has also been shown to decrease upon oil exposure, although recovery of normal pulsation was observed 96 hours after the coral was removed from the oil (Cohen et al., 1977). *Porites furcata* exposed to Marine Diesel and Bunker C oil reduced feeding and left their mouths open for much longer than normal (Reimer, 1975).

Direct oil contact may result in coral tissue damage. Coral exposed to sublethal concentrations of oil for 3 months revealed atrophy of muscle bundles and mucus cells (Peters et al., 1981). *Porites furcata* submersed in Bunker C oil for 1 minute resulted in 100 percent tissue death, although the effect took 114 days to occur (Reimer, 1975).

Reproductive ability may also be reduced if coral is exposed to oil. A hermatypic coral, *Stylophora pistillata*, and an octocoral, *Heteroxenia fuscescens*, neither of which are present in the Gulf of Mexico, but may show impacts similar to those that could occur in the Gulf, shed their larvae when exposed to oil (Loya and Rinkevich, 1979; Rinkevich and Loya, 1977; Cohen et al., 1977). Undeveloped larvae in the water column have a reduced chance of survival due to predation and oil exposure (Loya and Rinkevich, 1979), which would in turn reduce the ability of larval settlement and reef expansion or recovery. A similar expulsion of gametes may occur in species that have external fertilization (Loya and Rinkevich, 1979), such as those at the Flower Garden Banks (Gittings et al., 1992c), which may then reduce gamete survivorship due to oil exposure.

The overall ability of a coral colony to reproduce may be affected by oil exposure. Reefs of *Siderastrea siderea* that were oiled in a spill produced smaller gonads than unoiled reefs, which resulted in reproductive stress for the oiled reef (Guzmán and Holst, 1993). *Stylophora pistillata* reefs exposed to oil had fewer breeding colonies, reduced number of ovaria per polyp, and significantly reduced fecundity compared with unoiled reefs (Rinkevich and Loya, 1977). Impaired development of reproductive tissue has also been reported for other reef-building corals exposed to sublethal concentrations of oil (Peters et

al., 1981). Larvae may not be able to settle on substrate impacted by oil. Field experiments on *Stylophora pistillata* showed reduced settlement rate of larvae on artificial substrates of oiled reefs compared with control reefs and lower settlement rates, with increasing concentrations of oil in test containers (Rinkevich and Loya, 1977). Impaired larval settlement as a result of oiled substrate may lead to slow recovery of a disturbed substrate (CSA and GERG, 2001; MRRI, 1984; Montagna and Holmberg, 2000). Additionally, deeper habitats have slower rates of settlement, growth, and community development, and recruitment rates are reportedly slow in some live-bottom habitats (Montagna and Holmberg, 2000; CSA and GERG, 2001). It is possible that corals may not recruit to an oiled substrate for 10 years (MRRI, 1984).

Any hermatypic corals present on shallower live-bottom habitats may experience photosynthetic and growth impacts. Oil exposure is believed to reduce photosynthesis and growth in corals; however, low-level exposures have produced counterintuitive and sometimes immeasurable results. Photosynthesis of the zooxanthellae in *Diplora strigosa* exposed to approximately 18-20 ppm crude oil for 8 hours was not measurably affected, although other experiments indicate that photosynthesis may be impaired at higher concentrations (Cook and Knap, 1983). A longer exposure (24 hours) of 20 mL/L oil markedly reduced photosynthesis in *Stylophora pistillata*; however, concentrations of 2.5 mL/L oil resulted in physiological stress that caused a measurable increase in photosynthesis as compared with controls (Rinkevich and Loya, 1983). Other impacts recorded include the degeneration and expulsion of photosynthetic zooxanthellae upon coral exposure to oil (Loya and Rinkevich, 1979; Peters et al., 1981). Long-term growth changes in *Diploria strigosa* that was exposed to oil concentrations up to 50 ppm for 6-24 hours did not show any measurably reduced growth in the following year (Dodge et al., 1984).

Corals exposed to subsea oil plumes may also incorporate petroleum hydrocarbons into their tissue. Records indicate that *Siderastrea siderea*, *Diploria strigosa*, *Montastrea annularis*, and *Heteroxenia fuscescens* have accumulated oil from the water column and incorporated petroleum hydrocarbons into their tissues (Burns and Knap, 1989; Knap et al., 1982; Kennedy et al., 1992; Cohen et al., 1977). Most of the petroleum hydrocarbons were incorporated into the coral tissues, not their mucus (Knap et al., 1982). However, hydrocarbon uptake may also modify lipid ratios of coral (Burns and Knap, 1989). If lipid ratios are modified, mucus synthesis may be impacted, adversely affecting coral ability to protect itself from oil through mucus production (Burns and Knap, 1989). While these species are not present in the live-bottom (low-relief) areas, similar effects may occur in live-bottom species.

Sublethal effects, although often hard to measure, could be long lasting and affect the resilience of coral colonies to natural disturbances (e.g., elevated water temperature and diseases) (Jackson et al., 1989; Loya, 1976a). Continued exposure to oil from resuspended contaminated sediments could also impact coral growth and recovery (Guzmán et al., 1994). Any repetitive or long-term oil exposure could inhibit coral larvae's ability to settle and grow, may damage coral reproductive systems, may cause acute toxicity to larvae, and may physically alter the reef interfering with larval settlement, all of which would reduce coral recruitment to an impacted area (Kushmaro et al., 1997; Loya, 1975 and 1976a; Rinkevich and Loya, 1977). Exposure of eggs and larvae to oil in the water column may reduce the success of a spawning event (Peters et al., 1997). Sublethal exposure to oil may be more detrimental to corals than high concentrations of oil (Cohen et al., 1977), as sublethal concentrations are typically more widespread and have a larger overall community effect. Therefore, the sublethal effects of oil exposure, even at very low concentrations, may result in compounded community impacts that have long-lasting effects.

Dispersed Oil

Chemically-dispersed oil from a surface slick is not anticipated to result in lethal exposures to organisms on live-bottom features. The chemical dispersion of oil promotes the weathering process and increases the surface area available for bacterial biodegradation. It also allows surface oil to penetrate to greater depths than physical mixing would permit and the dispersed oil will generally remain below the water's surface (McAuliffe et al., 1981b; Lewis and Aurand, 1997). However, reports on dispersant usage on surface plumes indicate that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to stick to particles in the water column, minimizing sedimented oil traveling to the seafloor (McAuliffe et al., 1981a; Lewis and Aurand, 1997).

Field experiments designed to test dispersant use on oil spills reported dispersed oil concentrations between 1 and 3 ppm, 9 m (30 ft) below the sea surface, approximately 1 hour after treatment with dispersant (McAuliffe et al., 1981a and 1981b). Other studies indicated that dispersed oil concentrations were <1 ppm, 10 m (33 ft) below the sea surface (Lewis and Aurand, 1997). The above data indicate that the mixing depth of dispersed oil is less than the depths of the crests of most live-bottom features offshore, greatly reducing the possibility of exposure to dispersed surface oil. Features nearshore, in less than 10 m (33 ft) of water would be more susceptible to oil contact if oil reaches the area, but they are also farther from the CPA proposed action; this reduces their chance of contact and, if contact did occur, the oil would have more time to weather and biodegrade before contact.

Any dispersed surface oil that may reach the benthic communities of live-bottom features in the Gulf of Mexico would be expected to be at very low concentrations (less than 1 ppm) (McAuliffe et al., 1981a). Such concentrations would not be life threatening to larval or adult stages based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed oil in the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Dispersants that are used on oil below the sea surface can travel with currents through the water and may contact benthic organisms on the live-bottom features. If the oil spill occurs near a live-bottom feature, the dispersed oil could be concentrated enough to harm the community. However, the longer the oil remains suspended in the water column traveling with currents, the more dispersed it will become. Weathering will also be accelerated and biological toxicity reduced (McAuliffe et al., 1981b). Although the use of subsea dispersants is a new technique and very little data are available on dispersion rates, it is anticipated that any oil that could reach live-bottom features will be in low concentration based on surface slick dilution data (McAuliffe et al., 1981a; Lewis and Aurand, 1997). Impacts resulting from exposure to dispersed oil are generally anticipated to be sublethal.

The report of damage to deepwater corals on the continental slope (USDOI, BOEMRE, 2010i) as a result of exposure to oil from the DWH probably resulted from the use of dispersant at the source of the blowout. This situation was the first time subsea dispersants were used, and stratified density layers of water allowed the oil plume to remain at depth instead of dispersing into the water column (Joint Analysis Group, 2010a). The density bounded plume eventually contacted the coral. The decision to use subsea dispersants at the DWH was carefully weighed against the surrounding environment and anticipated environmental impacts. The decision to use subsea dispersants may not occur near protected habitats. For example, NOAA policy says that the application of dispersants must occur as far as possible from the Flower Garden Banks (Gittings, 2006). Also, because a stratified turbid watermass (the nepheloid layer) occurs near the seafloor on the continental shelf in the northwestern Gulf of Mexico no more than 20 m (66 ft) up into the water column, a depth that may engulf part or all of a live-bottom feature, decisionmakers probably would not select to use dispersants near the habitat.

Sublethal impacts that may occur to coral and other invertebrates exposed to dispersed oil may include reduced feeding, reduced photosynthesis, reduced reproduction and growth, physical tissue damage, and altered behavior. Short-term, sublethal responses of *Diploria strigosa* were reported after exposure to dispersed oil at a concentration of 20 ppm for 24 hours (Knap et al., 1983; Wyers et al., 1986). Although concentrations in this experiment were higher than what is anticipated for dispersed oil at depth, effects included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction, localized tissue rupture (Wyers et al., 1986), and a decline in tentacle expansion behavior (Knap et al., 1983). Normal behavior resumed within 2 hours to 7 days after exposure (Wyers et al., 1986; Knap et al., 1983). This coral, however, did not show indications of stress when exposed to 1 ppm and 5 ppm of dispersed oil for 24 hours (Wyers et al., 1986). *Diploria strigosa* exposed to dispersed oil (20:1, oil:dispersant) showed an 85 percent reduction in zooxanthellae photosynthesis after 8 hours of exposure to the mixture (Cook and Knap, 1983). However, the response was sublethal, as recovery occurred between 5 and 24 hours after exposure and return to clean seawater. Investigations 1 year after *Diploria strigosa* was exposed to concentrations of dispersed oil between 1 and 50 ppm for periods between 6 and 24 hours did not reveal any impacts to growth (Dodge et al., 1984; Knap et al., 1983). It should be noted, however, that subtle growth effects may have occurred but they were not measurable (Knap et al., 1983). This type of short-term exposure matches anticipated exposures, if any, to low-relief, live-bottom

features. Subsea oil plumes from a spill could be carried by currents to the features but would pass across or change directions, resulting in only short-term contact with any particular benthic feature. Many benthic organisms would return to normal in a few hours to days.

Historical studies indicate that dispersed oil appeared to be more toxic to coral species than oil or dispersant alone. The greater toxicity may be a result of an increased number of oil droplets, resulting in greater contact area between oil and water (Elgershuizen and De Kruijf, 1976). The dispersant causes a higher water soluble fraction of oil contacting the cell membranes of the coral (Elgershuizen and De Kruijf, 1976). The mucus produced by coral, however, can protect an organism from oil. Both hard and soft corals have the ability to produce mucus; mucus production has been shown to increase when corals are exposed to crude oil (Mitchell and Chet, 1975; Ducklow and Mitchell, 1979). Dispersed oil, which has very small oil droplets, does not appear to adhere to coral mucus, and larger untreated oil droplets may become trapped by the mucus barrier (Knap, 1987; Wyers et al., 1986). However, entrapment of the larger oil droplets may increase long-term exposure to oil if the mucus is not shed in a timely manner (Knap, 1987; Bak and Elgershuizen, 1976).

More recent field studies did not reveal as great an impact of dispersants on corals as were indicated in historical toxicity tests (Yender and Michel, 2010). This difference in reported damage probably resulted from a more realistic application of dispersants in an open field system and because newer dispersants are less toxic than the older ones (Yender and Michel, 2010). Field studies have shown oil to be dispersed to the part per billion level minutes to hours after the dispersant application, which is orders of magnitude below the reasonable effects threshold of oil in the water column (20 ppm) measured in some studies (McAuliffe, 1987; Shigenaka, 2001).

Although dispersed oil may be toxic to corals during exposure experiments (Shafir et al., 2007; Wyers et al., 1986; Cook and Knap, 1983), untreated oil may remain in the ecosystem for long periods of time, while dispersed oil does not (Baca et al., 2005; Ward et al., 2003). The time of year and surrounding ecosystem must be considered when determining if dispersants should be used. Dispersant usage may result in reduced or shorter term impacts to coral reefs; however, it may increase the impacts to other communities, such as mangroves (Ward et al., 2003). Therefore, dispersant usage may be more applicable offshore than in coastal areas where other species may be impacted as well. Dispersants also would probably not be approved during peak coral spawning periods (e.g., August-September for major reef-building species) (Gittings et al., 1992c and 1994) in order to limit the impacts of oil pollution on the near-surface portion of the water column.

Sedimented Oil (Oil Adsorbed to Sediment Particles)

Smaller suspended oil droplets could be carried to the seafloor as a result of oil droplets adhering to suspended particles in the water column. Smaller particles have a greater affinity for oil (Lewis and Aurand, 1997). Oiled sediment that settles to the seafloor may affect organisms attached to live-bottom features. It is anticipated that the greatest amount of sedimented oil would occur close to the spill, with lesser concentrations farther from the source. Studies after a spill that occurred at the Chevron Main Pass Block 41C Platform in the northern Gulf of Mexico revealed that the highest concentrations of oil in the sediment were close to the platform and that the oil settled to the seafloor within 5-10 mi (8-16 km) of the spill site (McAuliffe et al., 1975). Therefore, if the spill occurs close to a live-bottom feature, the underlying benthic communities may be exposed to toxic hydrocarbons. However, because of the prohibition of bottom-disturbing activity on low-relief, live-bottom features and the fact that they are not included in the area to be offered in the CPA proposed action, these hard-bottom communities should be distanced from the heaviest oiled sedimentation effects.

Some oiled particles may become widely dispersed as they travel with currents while they settle out of suspension. Settling rates are determined by size and weight of the particle, salinity, and turbulent mixing in the area (Poirier and Thiel, 1941; Bassin and Ichiye, 1977; Deleersbijder et al., 2006). Because particles will have different sinking rates, the oiled particles would be dispersed over a large area, most likely at sublethal or immeasurable levels. Studies conducted after the *Ixtoc* oil spill revealed that, although oil was measured on particles in the water column, measurable petroleum levels were not found in the underlying sediment (ERCO, 1982). Based on BOEMRE restrictions and the settling rates and behavior of sedimented oil, the majority of organisms that may be exposed to sedimented oil are anticipated to experience low-level concentrations.

Sublethal impacts to benthic organisms may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. Experiments have shown that the presence of oil on available substrate for larval coral settlement has inhibited larval metamorphosis and larval settlement (Kushmaro et al., 1997). Crude oil concentrations as low as 0.1 ppm on substrate upon which the coral larvae were to settle reduced larval metamorphosis occurrences by 50 percent after 8 days of exposure. Oil concentrations of 100 ppm on substrates only resulted in 3.3 percent of the test population metamorphosizing (Kushmaro et al., 1997). There was also an increased number of deformed polyps after metamorphosis due to oil exposure (Kushmaro et al., 1997). It is also possible that recurring exposure may occur to coral if sedimented oil is resuspended locally, possibly inhibiting coral growth and recovery in the affected areas (Guzmán et al., 1994). Oil stranded in sediment is reportedly persistent and does not weather much (Hua, 1999), so coral may be repeatedly exposed to elevated concentrations of oil.

Adult coral, however, may be able to protect itself from low concentrations of sedimented oil through mucus production. Coral mucus may not only act as a barrier to protect coral from the oil in the water column, it has been shown to aid in the removal of oiled sediment on coral surfaces (Bak and Elgershuizen, 1976). Coral may use a combination of increased mucus production and ciliary action to rid themselves of oiled sediment (Bak and Elgershuizen, 1976).

Blowout and Sedimentation

Oil or gas well blowouts are possible occurrences in the OCS. Benthic communities exposed to large amounts of resuspended sediments following a subsurface blowout could be subject to sediment suffocation, exposure to toxic contaminants, and reduced light. Should oil or condensate be present in the blowout flow, liquid hydrocarbons could be an added source of negative impact on the benthos.

Turbid waters allow less light penetrating to depth, which may result in reduced photosynthesis by the symbiotic zooxanthellae that live in hermatypic coral tissue and by calcareous algae (Rogers, 1990). Long-term exposures to turbidity have even resulted in significantly reduced skeletal extension rates in the scleractinian coral *Montastraea annularis* (Torres, 2001; Dodge et al., 1974) and acute decrease in calcification rates of *Madracis mirabilis* and *Agaricia agaricites* (Bak, 1978). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Suspended sediment that is transported by currents deep in the water column would not impact the benthic organisms on live-bottom features. Studies have shown that deep currents sweep around topographic features instead of over them, allowing the suspended sediment to remain at depth (Rezak et al., 1983; McGrail, 1982). A similar movement of water is anticipated around larger live-bottom features; therefore, suspended sediment or subsea oil plumes from depth would not be deposited on top of the elevated benthic organisms. However, lower relief features may experience slightly more deposition as currents may not sweep around them as much as the higher relief features.

Sediment that settles out of upper layers of the water column may impact benthic organisms of live-bottom features. Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, reducing light intensity, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced colony coverage, changes in species diversity and dominance patterns, alterations in growth rates and forms, decreased calcification, decreased photosynthesis, increased respiration, increased production in mucus, loss of zooxanthellae, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may also be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008). Gorgonian larvae, for example, only settle on substrate that does not have accumulated sediment (Grigg, 1977).

Impacts to corals as a result of sedimentation would vary based on coral species, the height to which the coral grows, degree of sedimentation, length of exposure, and the coral's ability to clear the sediment. Impacts may range from sublethal effects such as reduced growth, alteration in form, reduced recruitment and productivity, and slower growth to death (Rogers, 1990).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Scleractinian corals are tolerant of short-term sediment exposure and burial, but longer exposures may result in loss of zooxanthellae, polyp swelling, increased mucus production, reduced coral growth, and reduced reef

development (Marszalek, 1981; Rice and Hunter, 1992). Bleached tissue as a result of sediment exposure has been reported to recover in approximately a month (Wesseling et al., 1999).

Solitary octocorals and gorgonians, which are abundant on many hard-bottom features, are more tolerant of sediment deposition than colony-forming scleractinian corals because the solitary species grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992a). Many of these organisms have even been observed to grow tall enough to resist burial during periods of sediment encroachment (Lissner et al., 1991). Branching and upright forms of scleractinian corals, such as *Madracis mirabilis* and *Agaricia agaricites*, also tend to be more tolerant of sediment deposition than massive, plating, and encrusting forms, such as *Porites astreoides* (Roy and Smith, 1971; Bak, 1978). Some of the more sediment-tolerant scleractinian species in the Gulf of Mexico include *Montastraea cavernosa*, *Siderastrea siderea*, *Siderastrea radians*, and *Diploria strigosa* (Torres et al., 2001; Acevedo et al., 1989; Loya, 1976b). Due to the influence of the Mississippi River in the CPA, waters are more turbid near the outflow of the River, and more turbidity tolerant species are present on live bottoms in this portion of the Gulf of Mexico. Because many of the species are more tolerant of turbidity and sedimentation, they could better survive exposure to increased sediment input (Gittings et al., 1992a).

Since the BOEMRE-proposed stipulation would preclude bottom-disturbing activity near a low-relief, live-bottom feature, most adverse effects on live-bottom features from blowouts would likely be prevented. Petroleum-producing activities would be far enough removed that heavy layers of sediment suspended as a result of a blowout should settle out of the water column before they reach sensitive biological communities. Other particles that travel with currents should become dispersed as they travel, reducing turbidity and depositional impacts. Furthermore, sediment traveling at depth should remain at depth instead of rising to the top of live-bottom features.

Response Activity Impacts

Oil-spill-response activity may also impact sessile benthic features. Booms anchored to the seafloor are sometimes used to control the movement of oil at the water surface. Boom anchors can physically impact corals and other sessile benthic organisms, especially when booms are moved around by waves (Tokotch, 2010). Vessel anchorage and decontamination stations set up during response efforts may also break or kill hard-bottom features as a result of setting anchors. Anchor damage may result in the crushing and breaking of hard bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary species (cup corals, octocorals, and hydrocorals) may recolonize areas more rapidly than slow-growing colonial forms that disperse larval great distances (Lissner et al., 1991). Effort should be made to keep vessel anchorage areas away from sensitive benthic features to minimize impact.

Drilling muds comprised primarily of barite may be pumped into a well to stop a blowout. If a “kill” is not successful, the mud may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath the extruded drilling mud would be buried. Based on the Low Relief (Live Bottom) Stipulation (appended to NTL 2009-G39), a well should be far enough away from live-bottom features to prevent extruded drilling muds from smothering sensitive benthic communities. However, if drilling muds were to travel far enough or high enough in the water column to contact a hard-bottom community, the fluid may smother the existing community. Low-relief communities would be more at risk for burial than the higher features. Experiments indicate that corals perish faster when buried beneath drilling mud than when buried beneath carbonate sediments (Thompson, 1979). Turbidity impacts may result in reduced photosynthesis or reduced growth (Rogers, 1990; Torres, 2001). Light layers of deposited sediment would most likely be removed by mucus and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995).

Proposed Action Analysis

The BOEMRE blocks for which the Live Bottom (Low Relief) Stipulation applies are found in the EPA in water depths of less than 328 ft (100 m) and are located in the northeastern portion of the CPA. Although none of these blocks occur in an area to be offered by the CPA proposed action, a few of the blocks are adjacent to the area to be offered and are protected from impacts by oil gas activity through BOEMRE policies. Any impacting activity from a lease that extends beyond the area to be offered by the CPA proposed action into a live-bottom (low-relief) area would be restricted from contacting those sensitive habitats.

The fact that the live bottom (low-relief) features do not coincide with the area to be offered by the CPA proposed action and that they are widely dispersed, combined with the probable random nature of any potential oil-spill locations, would serve to limit the extent of damage from any given oil spill to a live-bottom (low-relief) community.

When surface spills are mixed into the water column, the oil is not expected to penetrate below a depth of about 10 m (33 ft). The water depths of blocks adjacent to live-bottom (low-relief) areas are much greater than 10 m (33 ft) (over 40 m; 130 ft). The use of dispersants could result in oil mixing into the water column and potentially reaching live-bottom (low-relief) communities.

Blowouts would not occur near live-bottom (low-relief) features since the habitats are not in the CPA sale area. Furthermore, blowouts in blocks adjacent to live-bottom (low-relief) features are unlikely to impact the biota because oil would rapidly float to the surface. Oil that is ejected under pressure may produce tiny droplets that become entrained in the water column and that could possibly affect the live-bottom (low-relief) communities. Sedimented oil or sedimentation as a result of a blowout would only reach a live-bottom (low-relief) community if both the blowout and the community are near the border of the CPA proposed action.

Potential impacts to the live-bottom (low-relief) communities adjacent to the CPA from oil spills and blowouts are unlikely and are not expected to be significant. Chemical spills are also infrequent, of small quantity, and usually occur in surface waters. The BOEMRE policies for live-bottom (low-relief) areas would assist in preventing most of the potential impacts from oil and gas operations, including accidental oil spills, blowouts, and chemical spills. No significant impacts to the live-bottom (low-relief) area adjacent to the CPA proposed action are expected.

Summary and Conclusion

Live-bottom features represent a small fraction of the continental shelf area in the CPA. The fact that the live-bottom features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the live-bottom features.

The depth below the sea surface to which many live-bottom features rise helps to protect them from surface oil spills. Because the concentration of oil becomes diluted as it physically mixes with the surrounding water and as it moves into the water column, any oil that might be driven to 10 m (33 ft) or deeper would probably be at concentrations low enough to reduce impact to these features. Features in water shallower than 10 m (33 ft) would be far from the source of activities in the CPA proposed action.

A subsurface spill or plume may impact sessile biota of live-bottom features. Oil or dispersed oil may cause sublethal impacts to benthic organisms if a plume reaches these features. Impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. The distance of proposed activities from low-relief live bottoms provides considerable protection for the habitats. The Live Bottom (Low Relief) Stipulation would limit the potential impact of any activities that may approach low-relief habitats (such as pipeline right-of-ways) because the stipulation keeps the sources of such adverse events geographically removed from the sensitive biological resources of live-bottom features. The distance would serve to reduce turbidity and sedimentation, and any sedimented oil should be well dispersed, resulting in a light layer of deposition that would have low toxicity and be easily removed by the organism.

The proposed Live Bottom (Low Relief) Stipulation would assist in preventing most of the potential impacts on live-bottom communities from blowouts, surface, and subsurface oil spills and the associated effects. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a live-bottom feature, the effects would be primarily sublethal

and impacts would be at the community level. Any turbidity, sedimentation, and sedimented oil would also be at low concentrations by the time the live-bottom features were reached, resulting in sub-lethal impacts.

Effects of the Proposed Action without the Proposed Stipulation

The live-bottom features and associated biota of the CPA could be adversely impacted by oil and gas activities resulting from the CPA proposed action should they not be excluded from the CPA proposed action or restricted by the proposed Live Bottom (Low Relief) Stipulation. This would be particularly true should operations occur directly on top of or in the immediate vicinity of otherwise protected live-bottom features. The area within the restricted zones would probably be the areas of the live-bottom features that are most susceptible to adverse impacts if oil and gas activities are not excluded or restricted by the Live Bottom (Low Relief) Stipulation. These impacting factors would include blowouts, surface oil spills, and subsea oil spills. Potential impacts from routine activities resulting from the CPA proposed action are discussed in **Chapter 4.1.1.6.2.2**.

Oil spills as well as routine activities have the potential to considerably alter the diversity, cover, and long-term viability of the biota found on live-bottom features. Direct oil contact may result in acute toxicity (Dodge et al., 1984; Wyers et al., 1986). In most cases, recovery from disturbances would take 10 years or more (MRRI, 1984; Fucik et al., 1984; Rogers and Garrison, 2001). Dispersants should not be applied near sensitive areas such as coral communities according to NOAA policy (Gittings, 2006). While not specifically regulated by the BOEMRE-proposed stipulation, their possible use is physically distanced by buffer zones created by BOEMRE stipulations. Dispersants could be applied at a spill close to sensitive features if the buffer zone between petroleum-producing activity and a sensitive feature is not written into the proposed stipulations. Indeed, disturbances, including oil spills and blowouts, would alter benthic substrates and their associated biota over large areas. In the unlikely event of a blowout, sediment resuspension (potentially with associated oil) could cause adverse turbidity and sedimentation conditions. In addition to affecting the benthic cover of a live-bottom feature, a blowout could alter the local benthic morphology, thus irreversibly altering the live-bottom community. Oil spills (surface and subsea) could be harmful to the local biota should the oil have a prolonged or recurrent contact with the organisms. Therefore, in the absence of the exclusions, the Live Bottom (Low Relief) Stipulation, or site-specific mitigations, the CPA proposed action could cause long-term (10 years or more) adverse impacts to the biota of the live-bottom features.

4.1.1.6.2.4. Cumulative Impacts

Background/Introduction

This cumulative analysis considers the effects of impact-producing factors related to the CPA proposed action plus those related to prior and future OCS lease sales, and to tanker and other shipping operations that may occur and adversely affect live bottoms of low-relief, hard-bottom areas. A description of live-bottom (low-relief) areas is given in **Chapter 4.1.1.6.2.1**. Specific OCS-related, impact-producing factors considered in the analysis are structure emplacement and removal, anchoring, discharges from well drilling, produced waters, pipeline emplacement, oil spills, blowouts, and operational discharges. Non-OCS-related impacts including commercial fisheries, natural disturbances, anchoring by recreational boats, and other non-OCS commercial vessels, as well as spillage from import tankering, all have the potential to alter live bottoms.

Oil and gas activities from this action do not coincide with the live-bottom (low-relief) habitats that are in the EPA and the northeast corner of the CPA; those blocks are excluded from the CPA proposed action. Some of the areas leased as a result of the CPA proposed action could be adjacent to the sensitive habitats at the extreme western edge of the habitat range. The Live Bottom (Low Relief) Stipulation prohibits bottom-disturbing activities in relevant blocks. Although those blocks are not in the area to be offered in the CPA proposed action, the stipulation would serve as a guideline for BOEMRE policy if activities in any adjacent blocks required right-of-way for construction or pipelaying. However, BOEMRE stipulations and mitigations do not protect the resources from activities outside of BOEMRE jurisdiction (i.e., commercial fishing, tanker and shipping operations, or recreational activities).

Severe and permanent physical damage may occur to low-relief features and the associated live bottoms as a result of non-OCS activities. It is assumed those biota associated with live bottoms of the CPA are well adapted to natural disturbances such as turbidity and storms; however, human disturbance could cause severe damage to live-bottom biota, possibly leading to changes of physical integrity, species diversity, or biological productivity. If such events were to occur, recovery to pre-impact conditions could take as much as 10 years (Fucik et al., 1984).

Non-OCS activities have a greater potential to affect the hard-bottom communities of the region than BOEMRE-regulated activities. Natural events such as storms, extreme weather, and fluctuations of environmental conditions (e.g., nutrient pulses, low dissolved oxygen levels, seawater temperature minima, and seasonal algal blooms) may impact live-bottom communities. Live-bottom (low-relief) communities occur from the shoreline to 100 m (328 ft) of water and, because many of these features are located in shallow water, storm events may damage these environments. Currents are created by wave action that can resuspend sediments to produce added turbidity and sedimentation (Brooks, 1991; CSA, 1992a). Storms can physically affect shallow-bottom environments, causing an increase in sedimentation, burial of organisms by sediment, a rapid change in salinity or dissolved oxygen levels, storm surge scouring, remobilization of contaminants in the sediment, and abrasion and clogging of gills as a result of turbidity (Engle et al., 2008). Storms have also been shown to uproot benthic organisms from the sediment (Dobbs and Vozarik, 1983) and breakage or detachment may occur as a result of storm activity (Yoshioka and Yoshioka, 1987). Such impacts may be devastating to a benthic community.

Hypoxic conditions of inconsistent intensities and ranges also occur annually in a band that stretches along the Louisiana-Texas shelf each summer (Rabalais et al., 2002). The dissolved oxygen levels of bottom waters in the Gulf of Mexico hypoxic zone are less than 2 ppm during part of the summer season. Such low concentrations are lethal to many benthic organisms and may result in the loss of some benthic populations. Although this is mainly a character of the Louisiana-Texas shelf, its effect could reach some live-bottom (low-relief) communities in the northeast portion of the CPA.

Recreational boating, fishing, and import tankering may severely impact local areas of live-bottom communities. Ships anchoring near major shipping fairways of the CPA or EPA may occasionally impact sensitive areas located near these fairways. Recreational and commercial fishermen also take advantage of the relatively shallow and easily accessible resources of the region and anchor at hard-bottom locations to fish. Much of the fishing on these habitats uses bottom fishing gear that may damage benthic organisms or may snag on the reefs and be lost. Such gear, particularly lines of varying thickness, can cut into the tissues of many benthic organisms during storm movement of bottom waters.

Damage resulting from commercial fishing, especially bottom trawling, may have a severe impact on hard-bottom benthic communities. Bottom trawling in the Gulf of Mexico primarily targets shrimp from nearshore waters to depths of approximately 90 m (300 ft) (NRC, 2002). Although trawlers would not select areas with sharp relief as fishing ground, since rocky areas may entangle gear, many live-bottom areas have little or no relief and may be targeted by trawlers. Reports indicate that bottom trawling activity on hard-bottom substrates can overturn boulders and destroy epifaunal organisms (Freese et al., 1999). Large emergent sponges and anthozoans may be particularly vulnerable to trawling activity, as these organisms grow above the substrate and can be caught and removed by trawling activity (Freese et al., 1999). Recovery rates of corals and coralline algae may take decades and depend on the extent of the impact, frequency of disturbance, other natural changes that occur to the habitat, and the organism's life history (NRC, 2002).

Structure placement and anchor damage from support boats and ships, floating drilling units, and pipeline-laying vessels that disturb areas of the seafloor are considered the greatest oil and gas OCS-related threat to low-relief, hard-bottom areas. The size of the areas affected by chains associated with anchors and pipeline-laying barges would depend on the water depth, chain length, sizes of anchor and chain, method of placement, wind, and current (Lissner et al., 1991). Anchor damage could include crushing and breaking of live bottoms and associated communities. It may also result in community alteration through reduced or altered substrate cover, loss of sensitive species, and a reduction in coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to corals as a result of anchoring may take 10 or more years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Nearby species on these hard-bottom habitats that disperse larvae short distances, such as solitary

species (cup corals, octocorals, and hydrocorals), may recolonize areas more rapidly than slow-growing colonial forms that disperse larvae great distances (Lissner et al., 1991).

Both explosive and nonexplosive structure-removal operations disturb the seafloor; however, they are not expected to affect live-bottom (low-relief) communities because they are not in the area to be offered in the CPA proposed action and because many sessile benthic organisms are known to resist the concussive force of structure-removal-type blasts (O'Keeffe and Young, 1984). Also, BOEMRE regulations require charges to be detonated 5 m (15 ft) below the mudline, which would attenuate shock waves in the seafloor (Baxter et al., 1982).

Routine discharges of drilling muds and cuttings by oil and gas operations could affect biological communities and organisms through a variety of mechanisms, including the smothering of organisms through deposition or less obvious sublethal toxic effects (impacts to growth and reproduction). The live-bottom (low-relief) areas, however, are not in the area to be offered in the CPA proposed action and are protected by the BOEMRE stipulation, including bottom shunting of drill cuttings away from the features if they are nearby. Even though the additive effects of drilling several wells adds more discharges to the environment, the CPA proposed action would be separated from the live-bottom (low-relief) communities by distance.

Drilling muds quickly disperse upon release and most of the material is rapidly deposited on the seafloor (Neff, 2005; Shinn et al., 1980; Hudson et al., 1982). The drilling fluid plume in the water column has been measured to be only a few milligrams per liter above background sediment concentrations 100 m (328 ft) from the discharge point, concentrations often less than those produced during storms or from boat wakes (Shinn et al., 1980). Deposition of drilling muds and cuttings in low-relief areas are not expected to greatly impact the biota of the surrounding habitat for two reasons. First, the biota near the CPA proposed action that live on the low-relief, hard-bottom communities are adapted to turbid conditions and storm impacts (Chiappone and Sullivan, 1994; Gittings et al., 1992a), reducing their vulnerability to sedimentation. Second, BOEMRE policy does not allow the disturbance of low-relief, hard-bottom communities and often requires bottom shunting of drilling material away from the sensitive habitat or requires that it be transported to approved disposal sites. Any exposure that may occur from muds and cuttings discharged as a result of the cumulative scenario would be temporary, primarily sublethal in nature, and the effects would be limited to small areas. Recovery to pre-impact conditions from these sublethal impacts would take place within 10 years (Fucik et al., 1984).

Produced waters from petroleum operations are not likely to have a great impact on live-bottom communities. Produced waters are rapidly diluted, impacts are generally only observed within proximity of the discharge point, and acute toxicity that may result from produced waters occurs "within the immediate mixing zone around a production platform" (Gittings et al., 1992b; Holdway, 2002). There have been no reported impacts to marine organisms or sediment contamination beyond 100 m (328 ft) of the produced-water discharge (Neff and Sauer, 1991; Trefry et al., 1995). Rapid dilution of surface discharges was reported within 6 m (20 ft) from the release point (Shinn et al., 1980; Hudson et al., 1982). Drilling discharges may be diluted 100 times at 10 m (33 ft) from the discharge and 1,000 times at 100 m (328 ft) from the discharge (Neff, 2005). Dilution continues with distance from the discharge point; at 96 m (315 ft) from the release point, Shinn et al. (1980) measured a plume as only a few milligrams per liter above background suspended sediment concentrations. Similar dilution factors can be expected for produced-water discharges. Because BOEMRE policy does not allow bottom-disturbing activities to impact live bottoms and because the habitats are not included in the area to be offered in the CPA proposed action, wells cannot be drilled in low-relief, hard-bottom features, eliminating the possibility of acute toxicity from the discharge. If any impacts were to occur, they would be sublethal and localized to habitats adjacent to the CPA proposed action.

Since many of the low-relief live bottoms are not included in the area to be offered in the CPA proposed action, and because of the Live Bottom (Low Relief) Stipulation and site-specific mitigations, operators are not expected to place pipelines directly upon live-bottom communities. The effect of pipeline-laying activities on the biota of these communities would be restricted to the resuspension of sediments, possibly causing obstruction of filter-feeding mechanisms of sedentary organisms and gills of fishes. Adverse impacts from resuspended sediments would be temporary, primarily sublethal in nature, and the effects would be limited to small areas. Impacts may include "changes in respiration rate, abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed

or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus" (Anchor Environmental CA, L.P., 2003).

Because many of the low-relief live bottoms are not included in the area to be offered in the CPA proposed action and because of the other BOEMRE protection policies, hard-bottom communities would be protected from experiencing direct oiling as a result of a blowout because bottom-disturbing activities are not permitted to impact these communities. However, surface oil spills and dispersed oil may impact hard-bottom communities. Disturbance of the sea surface by storms can mix surface oil 10-20 m (33-66 ft) into the water column (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). This may result in direct oil contact for shallow, nearshore live-bottom communities. Direct oiling may result in lethal impacts to organisms or sublethal responses such as reduced feeding (Lewis, 1971; Cohen et al., 1977; Reimer, 1975), tissue damage (Peters et al., 1981; Reimer, 1975), decreased reproductive ability (Loya and Rinkevich, 1979; Rinkevich and Loya, 1977; Cohen et al., 1977; Guzmán and Holst, 1993), reduced photosynthesis (Cook and Knap, 1983; Rinkevich and Loya, 1983; Loya and Rinkevich, 1979; Peters et al., 1981), incorporation of petroleum hydrocarbons into their tissue (Burns and Knap, 1989; Knap et al., 1982; Kennedy et al., 1992; Cohen et al., 1977), and reduced community resilience (Jackson et al., 1989; Loya, 1976a).

Live-bottom communities farther offshore, in deeper water, would be protected from direct physical oil contact by depth below the sea surface unless dispersants are used. Any dispersed surface oil from a tanker or rig spill that may reach the benthic communities of low-relief features in the Gulf of Mexico at a depth greater than 10 m (33 ft) would be expected to be at very low concentrations (less than 1 ppm) (McAuliffe et al., 1981a and 1981b; Lewis and Aurand, 1997). Such concentrations would not be life threatening to larval or adult stages, based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed or physically mixed oil in the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms, such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Potential blowouts are unlikely to impact the biota of the live-bottom features because they are not in the area to be offered in the CPA proposed action and because BOEMRE policy that does not allow drilling in areas of low-relief, hard-bottom communities. Therefore, these sensitive habitats are distanced from the potential lethal impacts of a blowout. If any blowouts from wells did occur, the suspended sediments should settle out of the water column before a majority of the material reached low-relief habitats. Any oil that becomes entrained in a subsurface plume will be dispersed as it travels in the water column (Vandermuelen, 1982; Tkalich and Chan, 2002). If oil were to contact the live-bottom features, concentrations should be sublethal, and the impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. In the highly unlikely event that oil from a subsurface spill could reach a coral-covered area in lethal concentrations, the recovery of this area could take in excess of 10 years (Fucik et al., 1984).

Should the live-bottom (low-relief) habitats not be excluded and the Live Bottom (Low Relief Stipulation not be implemented for the CPA proposed action or for future lease sales, OCS activities could have the potential to destroy part of the biological communities and damage one or several live/ hard-bottom features. The most potentially damaging of these are the impacts associated with physical damages that may result from anchors, structure emplacement, and other bottom-disturbing operations.

A recent report documents damage to a deepwater coral community 7 mi (11 km) southwest of the DWH blowout. Results are still pending, but it appears that a deepwater coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged (USDOI, BOEMRE, 2010j). Surface oil was also reported above some live-bottom features; however, results of field studies in the area are pending at this time (Boland et al., 2010).

The cumulative impacts of possible oil spills, along with the DWH event, are not anticipated to affect the overall live-bottom (low-relief) habitat. The limited data currently available on the impacts of the DWH event make it difficult to definitively say if any impacts have affected the live-bottom features in the CPA and EPA. It appears some impacts have occurred to corals within 7 mi (11 km) of the well. Water column sampling, however, indicated that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm, 40 and 45 nmi (74-83 km; 46-52 mi) northeast of the well (Haddad and Murawski, 2010), which is below concentrations known to cause acute toxicity, and are more likely

to cause low-level, short-term impacts to corals (Dodge et al., 1984; Wyers et al., 1986; Kushmaro et al., 1997). If oil is released near a low-relief feature and concentrated oil is entrained in the water column (by turbulent discharge or use of dispersant), it could contact nearby live-bottom habitat with serious detrimental effects. Habitats receiving high concentrations of oil could take 10 or more years to recover (Fucik et al., 1984). However, since subsea plumes travel directionally with water currents, only habitats directly in the path of the plume would be affected. Therefore, the acute impacts of any large-scale blowout would likely be limited in scale and any additive impacts of several blowouts should only impact small areas on an acute level, with possible sublethal impacts occurring over a larger area. Live-bottom (low-relief) communities are not included in the area to be offered in the CPA proposed action and are protected by other BOEMRE policies, so these sensitive communities would be distanced from any possible blowouts.

Summary and Conclusion

Non-OCS activities that may occur in the vicinity of the low-relief, hard-bottom communities include boating and fishing, import tankering, and natural events such as extreme weather conditions, and extreme fluctuations of environmental conditions. These activities could cause damage to the low-relief, hard-bottom communities. Ships using fairways in the vicinity of communities anchor in the general area of live bottoms on occasion, and commercial and recreational fishermen take advantage of the relatively shallow and easily accessible resources of regional hard bottoms. These activities could lead to instances of severe and permanent physical damage. During severe storms, such as hurricanes, large waves may reach deep enough to stir bottom sediments, which could cause severe mechanical damage to organisms, including abrasion from suspended sand, bruising and crushing from tumbling rocks, and complete removal of organisms (Brooks, 1991; CSA, 1992a). Yearly hypoxic events may affect portions of live-bottom benthic populations in the northeast part of the CPA (Rabalais et al., 2002).

Possible impacts from routine activities of OCS oil and gas operations include anchoring, structure emplacement and removal, pipeline emplacement, drilling discharges, and discharges of produced waters. In addition, accidental subsea oil spills or blowouts associated with OCS activities can cause damage to low-relief, hard-bottom communities. Long-term OCS activities are not expected to adversely impact the live-bottom environment, because these impact-producing factors are restrained by the continued implementation of protective lease stipulations and site-specific mitigations. The inclusion of the Live Bottom (Low Relief) Stipulation would preclude the occurrence of physical damage, the most potentially damaging of these activities. The impacts to the live/hard bottoms are judged to be infrequent because of the small number of operations in the vicinity of communities and the distance from the habitats. The impact to the live-bottom resource as a whole is expected to be slight because of the projected lack of community-wide impacts.

Impacts from blowouts, pipeline emplacement, muds and cuttings discharges, other operational discharges, and structure removals should be minimized because of the proposed Live Bottom (Low Relief) Stipulation and the dilution of discharges and resuspended sediments in the area. Potential impacts from discharges would be further reduced by USEPA discharge regulations and permit restrictions.

The incremental contribution of the CPA proposed action to the cumulative impact is expected to be slight, with possible impacts from physical disturbance of the bottom, discharges of drilling muds and cuttings, other OCS discharges, structure removals, and oil spills. Negative impacts should be restricted by the implementation of the Live Bottom (Low Relief) Stipulation, site-specific mitigations, and the distance of live-bottom habitats from the source of impacts.

4.1.1.7. Topographic Features

The BOEMRE has protected topographic features that support sensitive benthic communities since the early 1970's. The Gulf of Mexico seafloor in the CPA is mostly mud bottoms with varying mixtures of sand in some areas. Due to periods of lower sea level in geologic history, a thick layer of salt is present in a stratum deep beneath the seafloor. This salt becomes liquid under high pressure and pushes its way up through faults in the seafloor. In doing so, it sometimes forces up rock strata to form a "salt diapir" protruding up above the surrounding soft-bottom seafloor. Wherever these upthrusts of rock protrude into the water column, they form a rock reef that supports reef organisms that are different from those on

typical soft bottoms. These reefs are relatively rare on the seafloor compared with the ubiquitous soft bottoms (Parker et al., 1983). These topographic highs, or subsea banks, provide an island of hard substrate in a virtual ocean of soft bottoms. As a result, reef communities develop and include many of the more sensitive species associated with Caribbean waters.

"Topographic features" is a term that specifically refers to 37 subsea banks in the GOM that are protected from potential impacts by oil and gas activities. They are defined in this Agency's NTL 2009-G39, "Biologically-Sensitive Underwater Features and Areas," as "isolated areas of moderate to high relief that provide habitat for hard-bottom communities of high biomass and diversity and large numbers of plant and animal species, and support, either as shelter or food, large numbers of commercially and recreationally important fishes."

Over time, knowledge of these communities has increased and protective measures have evolved. This Agency has conducted environmental studies in the GOM for the past 35 years. Protective measures were instituted based on the nature and sensitivity of bank habitats and their associated communities. These protections have developed into stipulations applied to OCS leases. The lease stipulations establish five categories of protection zones: No Activity Zone; 1,000-Meter Zone; 1-Mile Zone; 3-Mile Zone; and the 4-Mile Zone. The No Activity Zone surrounds the core of the bank and prohibits any contact with the seafloor. The other zones are buffers with restrictions on the discharge of drill cuttings. All 37 banks have the No Activity Zone and may have up to two of the other zones. Details of the restrictions are described in this Agency's NTL 2009-G39. The Biological Stipulation Map Package (https://www.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G39.pdf) includes drawings of each bank with associated protection zones.

The BOEMRE has reexamined the analysis for topographic features presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below. New information supports the previous assessments contained in the Multisale EIS. Results of searches that were conducted for available data indicating the impacts to topographic features as a result of the DWH event have also been included in this assessment. The full analyses of the potential impacts of routine activities, accidental events, and cumulative impacts associated with the CPA proposed action are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections.

4.1.1.7.1. Description of the Affected Environment

A detailed description of topographic features can be found in Chapter 3.2.2.1.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.4.2 of the 2009-2012 Supplemental EIS. A search was conducted for additional new information published since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. Various Internet sources and journal articles were examined to discover any recent information regarding topographic features. Sources investigated include USGS, NOAA, USEPA, and coastal universities. Other sites were found through general Internet searches. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Topographic features are hard-bottom habitats and are rare compared with the ubiquitous soft bottoms in the GOM (Parker et al., 1983). They are typically upthrusts of rock due to uplift (salt diapirs) by underlying layers of salt deep under the seafloor. These topographic highs, or subsea banks, provide an island of hard substrate in a virtual ocean of soft bottoms.

Wherever rock protrudes up into the water column, reef organisms thrive. The type of organisms inhabiting a reef is determined by environmental conditions. Major factors are the amount of light and sedimentation and the temperature. If conditions are very good, a coral reef is established; this is found in the WPA only at the Flower Garden Banks. Other reefs (rocky upthrusts) are too dark or have too much sedimentation for hermatypic (reef-building) corals to thrive in numbers adequate to build a coral reef. However, these deeper reefs have thriving communities that include some stony corals as well as gorgonians, black corals, soft corals, sponges, urchins, crabs, many other invertebrates, macroalgae, calcareous algae, and a healthy fish community. The characteristics of protected topographic features in the GOM are described in more detail below.

The habitat created by the topographic features and the organisms found upon them is important for the following reasons:

- they support hard-bottom communities of high biomass, high diversity, and high numbers of plant and animal species;
- they provide shelter, food, and nursery grounds that support large numbers of commercially and recreationally important fishes;
- they are a unique and valuable component of the much larger ecosystem, providing essential functions not available elsewhere;
- they provide a relatively pristine area suitable for scientific research (especially the East and West Flower Garden Banks); and
- they have an aesthetically intrinsic value.

Figure 4-11 depicts the location of 37 protected topographic features in the GOM; 21 in the WPA and 16 in the CPA. In 1998, USGS, in cooperation with BOEMRE and the Flower Garden Banks National Marine Sanctuary, surveyed the East and West Flower Garden Banks using high-resolution, multibeam mapping techniques (Gardner et al., 1998). In 2002, the same consortium mapped 12 more topographic features, including Rankin (1 and 2) and MacNeil Banks in the WPA; and Alderdice, Sonnier, Geyer, Bright, Jakkula, Bouma, McGrail, Rezak, and Sidner Banks in the CPA (Gardner et al., 2002b).

A total of 16 topographic features are protected in the CPA. The BOEMRE has created "No Activity Zones" around major topographic features in order to protect these habitats from disruption due to oil and gas activities. A "No Activity Zone" is a protective perimeter associated with a specific depth contour that is drawn around each feature; no contact with the seafloor is allowed including the placement of structures, drilling rigs, pipelines, anchoring and cables. These No Activity Zones are areas protected by BOEMRE policy. The NTL 2009-G39 also recommends that drilling would not occur within 152 m (500 ft) of a No Activity Zone of a topographic feature. This additional recommendation is based on essential fish habitat; any construction within the buffer would require project-specific consultation with NOAA.

The surveys conducted by Gardner et al. (1998 and 2002b) revealed complex bathymetry in some areas surrounding the banks outside the No Activity Zones. Small seafloor features of moderate to high relief (8 ft [2.4 m] or higher) outside of the No Activity Zones of the larger banks are called "potentially sensitive biological features" and are considered important fish habitat. The potentially sensitive biological features provide surface area for the growth of sessile invertebrates and attract large numbers of fish. They are protected by BOEMRE from impacts of oil and gas activities as described by NTL 2009-G39 in that no bottom-disturbing activities may cause impacts to potentially sensitive biological features.

Benthic organisms on these topographic features are mainly limited by temperature, sedimentation, and low light. Extreme water temperature and light intensity are known to stress corals. Temperatures lower than 16 ^{o}C (60.8 ^{o}F) reduce coral growth, while temperatures in excess of 34.4 ^{o}C (93.2 ^{o}F) impede coral growth and induce coral bleaching (loss of symbiotic zooxanthellae) (Kleypas et al., 1999a). While intertidal corals are adapted to high light intensity, most corals become stressed when exposed to unusually high light levels. Furthermore, although corals will grow or survive under low light level conditions, they do best submerged in clear, nutrient-poor waters (Kleypas et al., 1999a).

Light penetration in the Gulf is limited by several factors including depth and events of prolonged turbidity. Hard substrates favorable to colonization by hermatypic coral communities in the northern Gulf are found on outer shelf, high-relief features. These substrates protrude above the nepheloid layer (layer of high turbidity) that lies above the muddy seafloor and are bathed most of the year in nutrient-poor waters (Rezak et al., 1990). The depth of these banks (18 m [59 ft] or more below the sea surface) reduces the effects of storms on the habitats. Whereas typical Caribbean shore reefs can suffer extensive damage from tropical storms, only the strongest storms reach down to reefs in the GOM. The most common influence of strong storms on these banks is an increase in turbidity, generally at the lower levels

of the banks (Rezak et al., 1990). Turbidity and sedimentation are normal in these lower levels because of the nepheloid layer and normal resuspension of soft bottom sediments.

Gulf of Mexico reefs span a range of environments, resulting in a range of community types. Habitats that can be classified as true coral reefs are few in the northern GOM: limited to the East and West Flower Garden Banks, a small area of McGrail Bank, and part of Pulley Ridge (in the eastern GOM). Other banks support reef communities with varying degrees of diversity, depending on environmental conditions. Many of these harbor a variety of corals, including some hermatypic corals, but not in densities that build a thriving, accreting coral reef. The banks of the GOM have been identified and classified into seven distinct biotic zones (Table 3-3 of the Multisale EIS) (modified/from Rezak and Bright, 1981; Rezak et al., 1983); however, none of the banks contain all seven zones. The zones are divided into the following four categories depending upon the degree of reef-building activity in each zone.

Zones of Major Reef Building and Primary Production

Diploria-Montastraea-Porites Zone

This zone is characterized by 18-20 hermatypic coral species and is only found at the East and West Flower Garden Banks in the WPA in water depths less than 36 m (118 ft) (Rezak et al., 1990). The dominant species/of the zone in order of dominance are the *Montastraea annularis complex* (this group includes *M. franksi*, *M. faveolata*, and *M. annularis*), *Diploria strigosa*, *Porites astreoides*, and *Montastraea cavernosa* (Precht et al., 2008; Robbart et al., 2009). Coralline algae are abundant in areas, which adds substantial amounts of calcium carbonate to the substrate and serves to cement the reef together. In addition to the coralline algae, there is a considerable amount of bare reef rock, which fluctuates in percent cover with the appearance of a red-turf like algae.

Typical sport and commercial fish and invertebrates observed in this zone include various grouper species; amberjack; barracuda; red, gray, and vermilion snapper; cottonwick; porgy; spiny lobsters; and shovel-nosed lobster (Rezak et al., 1983). There is also a diverse group of tropical reef fish species found on these banks, including creole fish; queen, stoplight, red band, and princess parrot fish; rock beauty; blue tang, and the whitespotted filefish, just to name a few. There are over 175 tropical reef species that reside within the high-diversity zone at the Flower Garden Banks (Dennis and Bright, 1988; Pattengill, 1998).

Madracis and Fleshy Algal Zone

The *Madracis* Zone is dominated by the small branching coral *Madracis mirabilis*, which produces large amounts of carbonate sediment (Rezak et al., 1990). In places, large (possibly ephemeral) populations of turf-like algae dominate the *Madracis* gravel substratum (Algal Zone). The *Madracis* Zone appears to have a successional relationship with the *Diploria*-*Montastraea*-*Porites* Zone. *Madracis* colony rubble builds up the substrate and allows the successional species to grow (Rezak et al., 1983). The zone occurs at the East and West Flower Garden Banks on peripheral components of the main reef structure between 28 and 46 m (92 and 151 ft) (Rezak et al., 1990).

Stephanocoenia-Millepora Zone

The *Stephanocoenia*-*Millepora* Zone is inhabited by a low-diversity coral assemblage of 12 hermatypic corals and can be found at McGrail, and Bright Banks in the CPA. The eight most conspicuous corals in order of dominance are *Stephanocoenia michelini*, *Millepora alcicornis*, *Montastraea cavernosa*, *Colpophyllia natans*, *Diploria strigosa*, *Agaricia agaricites*, *Mussa angulosa*, and *Scolymia cubensis* (Rezak et al., 1983). The assemblages associated with this zone are not well known; coralline algae is the dominant organism in the zone. The American thorny oyster (*Spondylus americanus*) is common in this zone along with populations of some reef fish (Rezak et al., 1983). The depth range of this zone is between 36 and 52 m (118 and 171 ft) (Rezak et al., 1990).

Algal-Sponge Zone

The Algal-Sponge Zone covers the largest area among the reef-building zones. Sonnier, McGrail, Geyer, and Bright banks all exhibit this community. The dominant organisms of the zone are the coralline algae, which are the most important carbonate producers. The algae produce nodules called "rhodoliths," which are composed of over 50 percent coralline algae, and form large beds on the seafloor. The rhodoliths range from 1 to 10 cm (0.4 to 4 in) in size, cover 50-80 percent of the bottom, and generally occur in water depths between 55 and 85 m (180 and 280 ft) (Rezak et al., 1983). The habitat created by the alga nodules supports communities that are probably as diverse as the coral-reef communities. Most of the leafy algae found on the banks occur in this zone and contribute large amounts of food to the surrounding communities. Calcareous green algae (*Halimeda* and *Udotea)* and several species of hermatypic corals are major contributors to the substrate (Rezak et al., 1983). Deepwater alcyonarians are abundant in the lower Algal-Sponge Zone. Sponges, especially *Neofibularia nolitangere,* are conspicuous. Echinoderms are abundant and also add to the carbonate substrate. Small gastropods and pelecypods are abundant (Rezak et al., 1983). Gastropod shells are known to form the center of some of the algal nodules. Characteristic fish of the zone are yellowtail reef fish, sand tilefish, cherubfish, and orangeback bass (Rezak et al., 1983).

Partly drowned reefs are a major substrate of the Algal-Sponge Zone. They are shallow carbonate reefs that are outpaced by sea-level rise and subsidence (Schlager, 1981). Their accumulation of carbonate is slower than relative sea-level rise so that, over time, they are found deeper and deeper in the water until they are no longer an accreting coral reef. In addition to the organisms typical to the rest of the Algal-Sponge Zone, the partly drowned reefs are also inhabited by large anemones, large comatulid crinoids, basket stars, limited crusts of *Millepora*, and infrequent small colonies of other hermatypic species (Rezak et al., 1983). The relief and habitat provided by the carbonate structures also attract a variety of fish species, especially yellowtail reef fish, reef butterfly fish, spotfin hogfish, orangeback bass, cherubfish, wrasse bass, longjaw squirrelfish, and several grouper species (Dennis and Bright, 1988).

Zone of Minor Reef Building

Millepora-Sponge Zone

The *Millepora*-Sponge Zone occupies depths comparable to the *Diploria-Montastraea-Porites* Zone on the claystone-siltstone substrate of the Texas-Louisiana midshelf banks. Sonnier Bank exhibits this community between 18 and 52 m (Robbart et al., 2009). One shelf-edge carbonate bank, Geyer Bank, also exhibits the zone but only on a bedrock prominence. Crusts of the hydrozoan coral, *Millepora alcicornis*, sponges, and other epifauna occupy the tops of siltstone, claystone, or sandstone outcrops in this zone. Scleractinian corals and coralline algae are rarely observed, largely due to seasonal temperatures that drop below the 18 ^{o}C (64 ^{o}F) minimum requirement for vigorous coral reef growth (Rezak et al., 1990).

Transitional Zone of Minor to Negligible Reef Building

Antipatharian Zone

This transitional zone is not distinct but blends in with the lower Algal-Sponge Zone. It is characterized by an abundance of antipatharian whips growing with the algal-sponge assemblage (Rezak et al., 1983). With increased water depth, the assemblages of the zone become less diverse, characterized by antipatharians, comatulid crinoids, few leafy or coralline algae, and limited fish (yellowtail redfish, queen angelfish, blue angelfish, and spotfin hogfish). Again, the depth of this zone differs at the various banks but generally extends to 90-100 m (295-328 ft) (Rezak et al., 1990).

Zone of No Reef Building

Nepheloid Zone

High turbidity, sedimentation, and resuspension occur in this zone. Rocks or drowned reefs are covered with a thin veneer of sediment and epifauna are scarce. The most noticeable are comatulid

crinoids, octocoral whips and fans, antipatharians, encrusting sponges, and solitary ahermatypic corals (Rezak et al., 1990). The fish fauna is different and less diverse than those of the coral reefs or partly drowned reefs. These fish species include red snapper, Spanish flag, snowy grouper, bank butterflyfish, scorpionfishes, and roughtongue bass (Rezak et al., 1983). This zone occurs on all banks, but its depth differs at each bank. Generally, the Nepheloid Zone begins at the limit of the Antipatharian Zone and extends to the surrounding soft bottom (Rezak et al., 1990).

Banks of the Central Planning Area

Shelf-Edge Banks	Midshelf Banks	South Texas Banks
Alderdice Bank Bouma Bank Bright Bank Diaphus Bank Elvers Bank Ewing Bank Geyer Bank Jakkula Bank McGrail Bank Parker Bank Rezak Bank Sidner Bank Sweet Bank	Fishnet Bank Sackett Bank Sonnier Bank	WPA Only

Shelf-Edge Banks

The shelf-edge banks of the Central Gulf (Geyer, Sackett, Diaphus, Alderice, McGrail, and Bright) (**Figure 4-11**) generally exhibit the *Algal-Sponge* zonation (where present) that transitions into the deep, turbid Nepheloid Zone that is exhibited at these Banks (Rezak et al., 1983). However, Geyer Bank (37 m [121 ft] crest), which is within the depth of the high-diversity, coral-reef zone, does not exhibit the high-diversity characteristics. Instead, Geyer Bank has a well-developed *Millepora*-Sponge Zone, which is typically the defining characteristic of midshelf banks found elsewhere in the GOM (Rezak et al., 1983). The hydrocoral Millepora and various sponges have dominated the reef crests in the past. A surprising quantity of a benthic *Sargassum* macroalgae was documented by Robbart et al. (2009) in a recent study. The algae grows up to about a 0.5 m (1.5 ft) tall, providing considerable upright structure and cover for invertebrates and fish over a large portion of the reef cap. Upper portions of the bank house small branching corals (*Madracis*), leafy calcareous algae (*Peyssonnelia*), calcareous green algae (*Halimeda*), small agariciid coral colonies, ellisellid sea whips, Cirrhipathes, gastropods, sponges (*Chelotropella*), and crinoids (Rezak et al., 1983). Deeper portions of the Bank provide habitat for small sponges, solitary corals (*Oxysmilia*), branching corals (*Oculina*), octocorals (*Nidalia*), and octocoral fans (Rezak et al., 1983). A coherent mud is present at the bottom of the bank and small ophiuroids, hermit crabs, galatheid crustaceans, swimming scallops, urchins, and flatfishes were observed occupying the sediment (Rezak et al., 1983).

Sackett and Diaphus Banks (**Figure 4-11)** are closest to the Mississippi River and have less diverse communities than other banks as a result of the turbid waters (Rezak et al., 1983). A thin veneer of sediment covers much of Sackett Bank and species present include: comatulid crinoids, encrusting sponges, urchins, black corals, Atlantic thorny oyster, saucer-shaped agariciids, and coralline algae (Rezak et al., 1983). Turbidity tolerant species were present in the Nepheloid Layer including: comatulid crinoids, sponges (*Neofibularia*), white fire worms (*Hermodice*), asteroid star fish (*Narcissia trigonaria*), black corals (*Cirrhipathes*), white sponge (*Geodea*), branching antipatharians (*Antipathes*), club-shaped octocorals (*Nidalia occidentalis*), sea fans, stony corals (*Oxysmilia*), paramuriceids (*Nidalia*), and large solitary corals (Rezak et al., 1983). Diaphus Bank has many drowned reef patches and very little live cover or active growth due to the turbid waters and sediment veneer (Rezak at al., 1983).

Alderice Bank (**Figure 4-11**) is also influenced by the turbidity of the surrounding water. Black corals, sponges, and bryozoans are present at the crest. Below the crest, drowned reef structures appear

with sediment-covered mats of low epifaunal growth (Rezak et al., 1983). The deeper muddy bottom houses mobile benthic invertebrates such as the sand dollar (*Clypeaster ravenelli*) and starfish (*Narcissia trigonaria*). Two basalt spires protrude from this bank and attract schools of roughtongue bass, yellowtail reeffish, creole fish, vermillion snapper, grouper, and jacks (Schmahl et al., 2003; Weaver et al., 2006). The community is heavily dominated by roughtongue bass (Weaver et al., 2006).

The crest of McGrail Bank (45 m, 148 ft) (**Figure 4-11**) is dominated by macroalgae communities having about 38 percent cover. Hermatypic corals are common on the crest with a limited area of up to 32 percent coral cover. It is one of the few banks in the northwestern Gulf of Mexico that has reef-building corals other than the East and West Flower Garden Banks (Schmahl et al., 2003). The bank exhibits a *Stephanocoenia-Millepora* Zone and some relatively high coral coverage compared to other banks in the area. Corals observed on this bank include: *Stephanocoenia intersepta*, *Millepora alcicornis*, *Diploria strigosa*, *Montastraea cavernosa*, *Colpophyllia natans*, *Agaricia lamarcki*, and *Agaricia undata* (Schmahl et al., 2003; Schmahl and Hickerson, 2006). *Stephanocoenia intersepta* is the dominant coral in this zone. Fleshy green, brown, and red algae species including: *Dictyota pulchella*, *Lobophora variegate*, *Peyssonnelia inamoena*, *Codium isthmocladum*, *Codium interextum*, *Anadtomene lacerate*, and *Caulerpa racemosa* are abundant (Schmahl and Hickerson, 2006). Planktivorous fish such as creole fish, threadnose bass, yellow goatfish, sunshinefish, school bass, bicolor damselfish, and blue chromis dominated the fish community (Schmahl and Hickerson, 2006; Weaver et al., 2006). Deeper regions of the bank exhibit deep water corals such as antipatharians, solitary corals, and branching corals (*Oculina* and *Madrepora*) (Schmahl and Hickerson, 2006). McGrail Bank has also experienced mechanical disturbance and damage from fishing and anchoring and marine debris has been found at the bank (Schmahl and Hickerson, 2006).

Bright Bank (**Figure 4-11**) is located in deep water with its highest peak at 33 m (108 ft) below the sea surface (Robbart et al., 2009). The benthic community is dominated by a very high live cover of about 86 percent, with brown, green, and turf algae as the dominant groups. Coral cover is about 8 percent. Bright Bank exhibits a *Stephanocoenia-Millepora* Zone with sponges and scleractinian corals (*Montastraea cavernosa*, *Stephanocoenia intersepta*, and *Diploria strigosa*) (Robbart et al., 2009; Schmahl and Hickerson, 2006). A mud volcano, drowned reef formations, and hydrocarbon seeps have also been identified on this bank (Schmahl et al., 2003). Salvage activity searching for a historic shipwreck destroyed some coral heads at this bank in the 1980s; excavation activity may have taken place as recently as 2001 (Schmahl and Hickerson, 2006).

It has been suggested that Phleger Bank be considered a sensitive offshore topographic feature. Phleger Bank (**Figure 4-11**) crests at 122 m (400 ft), deeper than the lower limit of the No Activity Zones (85 m (279 ft) [100 m (328 ft) in the case of the Flower Gardens]). The depth of the bank precludes the establishment of the Antipatharian Zone so that even though the bank is in clear water, the biota is typical of the Nepheloid Zone (Rezak et al., 1983). The bank appears to be predominantly covered with sand, with scattered rock outcrops of approximately 1-2 m (3-7 ft) in diameter and 1 m (3 ft) in height (CSA, 1980). The sand substrate is devoid of sessile benthic organisms, although the rock outcrops support a number of epifaunal species such as cup-shaped and encrusting sponges, octocorals, and crinoids. Roughtongue bass were observed in video surveys to be the dominant fish species on this bank (CSA, 1980).

Midshelf Banks

Two midshelf banks in the CPA contain the *Millepora*-Sponge Zone: Sonnier and Fishnet Banks (**Figure 4-11**). These banks are associated with underlying salt diapirs and rise from depths of 80 m or less. The dominant species on these banks are hydrozoan fire corals (*Millepora*) and sponges (Rezak et al., 1983).

Sonnier Bank (**Figure 4-11**), which consists of eight peaks and banks, and has a crest at approximately 20 m, is encrusted with fire coral (*Millepora alcicornis*) and sponges (*Neofibularia nolitangere* and *Ircina*). With depth, fire coral coverage is reduced and encrusting sponge coverage is increased (Weaver et al., 2006). A unique biological assemblage occurs at each of the peaks, which is influenced by the depths of the peak and the nepheloid layer (Weaver et al., 2006). Hermatypic anthozoan corals (*Stephanocoenia michelini*) which tolerate low light levels and moderate turbidity were reported between 36 and 41 m (Rezak et al., 1983). Planktivorous fish dominate this bank, with the most

abundant species being yellowtail reeffish, creole fish, brown chromis, sunshine fish, and bluehead (Weaver et al., 2006). Angelfish, butterflyfish, damselfish, bluehead, hogfish, rock hind, grouper, Vermilion snapper, and red snapper also utilize this bank (Rezak et al., 1983). The crests of the bank were dominated by creole fish, brown chromis, bluehead, and creole wrasse and the deeper portions of the reef were dominated by tomtate, red snapper, greater amberjack, and grey triggerfish (Weaver et al., 2006). Benthic organisms occupying the turbid soft-bottom sediment at the base of the Bank include: antipatharians (*Cirrhipathes* and *Antipathes*), comatulid crinoids, sponge (*Ircinia campana*), hovering goby (*Ioglossus calliurus*), blue goby (*Ptereleotris calliurus*), tattler (*Seranus phoebe*) and large infaunal and mobile benthic species (Rezak et al., 1983; Weaver et al., 2006).

Recent Invasive Species Concerns

Two invasive species have been reported in the Gulf of Mexico: the orange cup coral (*Tubastraea coccinea*) and the lionfish (*Pterois volitans/miles*). Invasive species are organisms that are not native to the local environment and have the potential to outcompete native species. *Tubastraea coccinea*, which is reported on many oil and gas platforms in the northern Gulf of Mexico, has been reported at both Geyer and Sonnier Banks (Hickerson et al., 2008; Fenner and Banks, 2004; Sammarco et al., 2004). Over 100 colonies were reported at Geyer Bank (Hickerson et al., 2008). The lionfish has been reported off the coasts of Florida, Alabama, and Louisiana in 2010 (USDOI, GS, 2010b). Reports of this species began in 2006 in Florida, but the species was confirmed in the northern Gulf of Mexico in 2010 (Schofield, 2009; USDOI, GS, 2010b). It has also recently been reported in the Southern Gulf of Mexico (Aguilar-Perera and Tuz-Sulub, 2010). Specific sitings were noted at Sonnier Bank and several oil and gas platforms in the CPA (USDOI, GS, 2010b).

Proposed Candidates for Threatened and Endangered Species

Elkhorn coral (*Acropora palmata*), which was listed as "threatened" in 2006 and is protected under the ESA, has been documented in the WPA at the East and West Flower Garden Banks. In 2009, a petition was submitted to NOAA Fisheries by the Center for Biological Diversity to list 82 additional species of coral under the ESA (USDOC, NOAA, 2010h). Those 82 "candidate species" are currently under review by NOAA Fisheries. Some of the "candidate species" are found in the Gulf of Mexico, including *Montastraea annularis*, *Montastraea faveolata*, *Montastraea franksi*. Once NOAA Fisheries has reviewed the candidate species, a decision would be made as whether each species warrants listing under the ESA or not. If these species are listed, they would receive protection under the ESA.

Hurricane Impacts on CPA Banks

Severe hurricanes can cause physical damage to reef structure and organisms. On September 23, 2005, Hurricane Rita passed over the northwestern Gulf of Mexico, affecting at least 18 topographic features. The BOEMRE has conducted studies of select topographic features since Hurricane Rita. An Agency-funded study, *Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity* (Robbart et al., 2009), investigated hurricane effects at Sonnier, McGrail, Geyer, and Bright Banks. Preliminary results suggest little hurricane damage to McGrail, Geyer, and Bright Banks but severe damage at Sonnier Bank (Robbart et al., 2009). The impact assessment was conducted 20 months after the hurricane, and McGrail, Geyer, and Bright Banks were primarily dominated by algae and sponges, so it is difficult to determine if there was no damage initially or if the banks have shown recovery.

Speculation is that Sonnier Bank was more affected by Hurricane Rita because of its shallower depth and position on the east side of the storm track. Live cover was reduced at this bank and the disappearance of the sponge colonies, *Xestospongia muta*, was notable (Robbart et al., 2009). The community structure had visibly changed from pre-Rita (2004) studies at this bank (Kraus et al., 2006; Kraus et al., 2007). In 2006, the habitat was dominated by algae, indicating an alteration in habitat after Hurricane Rita (Kraus et al., 2007). The algal cover, however, was the beginning of recovery of the storm-impacted areas, which was farther colonized with sponges (Robbart et al., 2009). Fish community shifts were also observed on Sonnier Banks after Hurricane Rita as opposed to before the storm, but clear links have yet to be made to the storm (Kraus et al., 2007).

This new information illustrates the potential effects of natural events, especially the cumulative impacts of hurricanes. Some change has been detected in habitats affected by Hurricane Rita, mostly the degradation of the reef community at Sonnier Bank. Other banks either had no substantive damage or are recovering well.

Baseline Conditions Following the *Deepwater Horizon* Event

The following sections contain all new data since the Multisale EIS and the 2009-2012 Supplemental EIS. Extensive literature, Internet, and database searches have been conducted for results of scientific data at topographic features following the DWH event. Although many research cruises have occurred, very few reports containing data have been released as of the preparation of this Supplemental EIS. Descriptions of studies in progress are discussed and any results indicated are included.

It is unlikely that the topographic features of the CPA have been impacted by the DWH event because of their distance from the oil spill and their position on the continental shelf. The nearest protected topographic feature is Sackett Bank, which is 116 km (72 mi) from the spill site. Beyond that, the next nearest feature is Diaphus Bank, approximately 240 km (150 mi) away. The bulk of the oil was dispersed in deep water off the shelf and was be directed by water currents in deep water. These currents do not typically transit from deep water up onto the shelf. Oil dispersed on the sea surface could have traveled onto the continental shelf but the distance from the DWH event to protected topographic features makes it unlikely to reach the banks. As a result, it is anticipated that there will be no change in existing baseline conditions. The benthic communities on the topographic features are anticipated to remain a diverse and highly productive habitat that supports a variety of coral, sponge, algal, invertebrate, and fish species.

If any impacts do occur, they would be a result of low-level or long term exposure to dispersed oil. Impacts may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment (Kushmaro et al., 1997; Loya, 1975 and 1976a; Rinkevich and Loya, 1977). It would likely be difficult to distinguish the source of any possible low-level impacts because numerous natural seeps in the CPA are constantly releasing oil into the water. Possible impacts may be investigated in future studies if deemed necessary by the NRDA.

Studies to Measure the Impact of the *Deepwater Horizon* Event

Many studies have been planned to analyze the impact of the DWH event and some have already been carried out. However, the long-lasting impacts of this event will take years to determine. As more studies are conducted and more data is released, we will have a better understanding of the breadth of the effects of the DWH event. The following descriptions outline studies that have been conducted on topographic features, most of which have taken place at the Flower Garden Banks which are in the WPA.

Florida Atlantic University, Harbor Branch Oceanographic Institute has conducted a study entitled “Rapid Response to the *Deepwater Horizon* Oil Spill” exploration of the Florida Shelf Edge. Although data have not been published at the time of this Supplemental EIS’s release, the characterization of benthic and mid-water habitats was conducted from July 9 to August 7, 2010 (Pomponi, 2010). Mission objectives of the exploration included the following: (1) assess benthic and mid-water habitat baseline and oil impact (assessments that targeted deepwater and shelf-edge reefs and hard-bottom essential fish habitat; (2) document oil and dispersant impacts on benthic and mid-water habitats and marine organisms; (3) document location of any encountered submerged oil plumes; and (4) conduct education and outreach activities. The survey’s primary focus was on the west Florida shelf. Deepwater sites (>200 m; 656 ft) that were studied included *Lophelia* coral habitat (Viosca Knoll, Mississippi Canyon, and De Soto Canyon) and the west Florida shelf lithotherms (500 m; 1,640 ft) (Pomponi, 2010).

The NOAA R/V *Seward Johnson* conducted a baseline survey of the water column and seafloor in areas of the GOM from which the data will be used to measure changes if oil from the DWH event reaches the areas investigated (USDOC, NOAA, 2010g). Submersibles and remotely operated vehicles were used to observe baseline conditions of coral reefs and benthic organisms along the deep reef and hard-bottom regions of the east, south, and west Florida shelf and slope. The research cruise followed a path from the *Oculina* reefs off southeast Florida, through the Straits of Florida to the Dry Tortugas, north through the eastern and northern GOM, and west along the Florida shelf and slope toward Alabama and Mississippi (USDOC, NOAA, 2010g).

The limited data currently available on the impacts of the DWH event make it difficult to definitively say if any impacts have occurred or may occur to the topographic features in the CPA. Once more data are released, we will have a better understanding of the measured impacts and possible long-term effects of the DWH event. The implementation of the proposed Topographic Features Stipulation, however, would serve to protect sensitive habitat from accidental impacts from oil and gas production, such as oil spills, by distancing production from the protected habitat. Details of how the proposed Topographic Features Stipulation protects reefs and banks in the Gulf of Mexico from routine and accidental impacts of petroleum production are discussed below.

4.1.1.7.2. Impacts of Routine Events

The vast majority of the Gulf of Mexico seabed is comprised of soft sediments. Topographic features formed on hard-bottom substrate are interspersed along the continental shelf above the soft sediment. These topographic features, which sustain sensitive offshore habitats in the CPA, are listed and described in **Chapter 4.1.1.7.1**.

The potential impact-producing factors on topographic features of the CPA are anchoring, infrastructure emplacement, drilling-effluent and produced-water discharges, and infrastructure removal. Impacts from accidental events such as oil spills and blowouts are discussed in **Chapter 4.1.1.7.3.** These disturbances have the potential to disrupt and alter the environmental, commercial, recreational, and aesthetic values of topographic features in the CPA.

A Topographic Features Stipulation similar to the one described in **Chapter 2.3.1.3.1** has been included in appropriate leases since 1973 and may, at the option of the Secretary, be made a part of appropriate leases resulting from this proposed action. The impact analysis of routine activities associated with the CPA proposed action presented here includes the proposed Topographic Features Stipulation. As noted in **Chapter 2.3.1.3.1**, the proposed stipulation establishes a No Activity Zone in which no bottom-disturbing activities would be allowed, and areas around the No Activity Zones (in most cases) within which shunting of drill cuttings and drilling fluids to near the bottom would be required.

Construction Impacts on Topographic Features

The anchoring of pipeline lay barges, drilling rigs, or service vessels, as well as the emplacement of structures (e.g., pipelines, drilling rigs, or production platforms), results in mechanical disturbances of the benthic environment. Anchor damage has been shown to be a large threat to the biota of the offshore banks in the Gulf (Rezak and Bright, 1979; Rezak et al., 1985; Gittings et al., 1992a; Hudson et al., 1982). Anchors may break, fragment, or overturn corals and the anchor chain may drag across and catch on coral (Dinsdale and Harriott, 2004). Coral colonies may experience abrasion of tissue and skeletons, death to portions of a colony, fragmentation, or removal from substrate as a result of anchor damage (Dinsdale and Harriott, 2004). Branching species tend to experience fragmentation while massive species incur surface damage (Marshall, 2000). Anchor damage may result in community alteration through reduced coral cover, which indirectly promotes an increase in algal cover, complete coral removal, loss of sensitive species, reduction in colony size, and a reduction in soft coral cover in heavily damaged areas (Dinsdale and Harriott, 2004). Damage as a result of anchoring in a coral community may take 10 or more years from which to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001). Such anchoring damage, however, would be prevented within any given No Activity Zone by the observation of the proposed Topographic Features Stipulation, which does not allow bottom-disturbing activity.

Infrastructure emplacement and pipeline emplacement could result in suspended sediment plumes and sediment deposition on the seafloor. Considering the relatively elevated amounts of drilling muds and cuttings discharged per well (approximately 2,000 metric tons [2,205 tons] for exploratory wells, i.e., 900 metric tons [992 tons] of drilling fluid and 1,100 metric tons [1,213 tons] of cuttings) and slightly lower discharges for development wells) (Neff, 2005), potential impacts on biological resources of topographic features should be expressly considered if drill sites occur in blocks directly adjacent to No Activity Zone boundaries. Potential impacts could be incurred through increased water-column turbidity, the smothering of sessile benthic invertebrates, and local accumulations of contaminants.

However, the proposed Topographic Features Stipulation requires all bottom-disturbing activity to be at least 152 m (500 ft) away from the boundaries of No Activity Zones. The proposed Topographic

Features Stipulation limits impact through the No Activity Zone and shunting restrictions imposed within the 1-Mile Zone, 3-Mile Zone, 4-Mile Zone, and 1,000-Meter Zone. This would prevent well drilling activities from occurring in the No Activity Zone and preclude most resuspended sediments from reaching the biota of the banks. Also, USEPA's NPDES permit sets special restrictions on discharge rates for muds and cuttings adjacent to topographic features bound by a No Activity Zone. Chapters 4.1.1.4.1 and 4.2.1.1.2.2 of the Multisale EIS detail the NPDES permit's general restrictions and the impacts of drilling muds and cuttings on marine water quality and seafloor sediments. Due to the Topographic Features Stipulation and USEPA discharge regulations, turbidity and smothering impacts of sessile invertebrates on topographic features caused by drilling muds and cuttings are unlikely.

The proposed Topographic Features Stipulation would protect topographic features by physical distance from drilling activities. Drilling fluid plumes are rapidly dispersed on the OCS where approximately 90 percent of the material discharged in drilling a well (cuttings and drilling fluid) settles rapidly to the seafloor, while 10 percent forms a plume of fine mud that drifts in the water column (Neff, 2005). The composition of muds is strictly regulated, and discharges of cuttings/muds are tested to ensure that toxicity levels are below the limits allowed by NPDES permits (USEPA, 2004a, 2007d, and 2009a). Although drilling mud plumes may be visible 1 km (0.6 mi) from the discharge, rapid dilution of drilling mud plumes was reported within 6 m (20 ft) from the release point (Shinn et al., 1980; Hudson et al., 1982). Drilling muds and cuttings may be diluted 100 times at 10 m (33 ft) from the discharge and 1,000 times at 100 m (328 ft) from the discharge (Neff, 2005). Dilution continues with distance from the discharge point, and at 96 m (315 ft) from the release point, the plume was measured only a few milligrams/liter above background suspended sediment concentrations (Shinn et al., 1980). Suspended sediment concentrations at 6 m (20 ft) from the discharge were often less than those produced during storms or from boat wakes (Shinn et al., 1980).

It is not anticipated that muds drifting in the water column would settle on topographic features. The mud particles are extremely fine and would not be able to settle in the high-energy environments surrounding topographic features (Shinn et al., 1980; Hudson and Robbin, 1980). Any mud that may reach coral can be removed by the coral using tentacles and mucus secretion, and physically removed by currents that can shed the mucus-trapped particles from the coral (Shinn et al., 1980; Hudson and Robbin, 1980). Considering that drilling is not allowed within 152 m (500 ft) of a No Activity Zone, that shunting to within 10 m (33 ft) of the bottom is required surrounding the No Activity Zone, and that field measurements of suspended solids far below concentrations that cause coral mortality corals 96 m (315 ft) from the discharge point (Shinn et al., 1980), corals should be distanced enough from the effects from drilling turbidity.

Due to the proposed Topographic Features Stipulation, impacts measured as a result of drilling operations would be minimal in comparison to impacts without the proposed Topographic Features Stipulation. Wells drilled in lease blocks containing topographic features would be required to shunt cuttings to within 10 m (33 ft) of the seafloor. Bottom shunting would protect the organisms on the topographic features because it results in localized deposition of cuttings at a greater depth than the biological activity of the topographic features (Neff, 2005). Therefore, the deposited material is not anticipated to reach the benthic organisms on the reef.

Long-Term and Operational Impacts on Topographic Features

Both distance from drilling operations and shunting of cuttings to the seafloor are anticipated to reduce exposure pathways of drilling activities to benthic organisms on topographic features, eliminating long-term operational impacts, such as exposure to turbidity and sedimentation or associated contaminants.

Produced waters are discharged at the water surface throughout the lifetime of the production platform and may contain hydrocarbons, trace metals, elemental sulfur, and radionuclides (Kendall and Rainey, 1991). Heavy metals enriched in the produced waters include cadmium, lead, iron, and barium (Trefry et al., 1995). Produced waters may impact both organisms attached to the production platform and benthic organisms in the sediment beneath the platform. A detailed description of the impacts of produced waters on water quality and seafloor sediments is presented in Chapter 4.2.1.1.2 of the Multisale EIS.

Produced waters are rapidly diluted and impacts are generally only observed within proximity of the discharge point (Gittings et al., 1992a). Past evaluation of the bioaccumulation of offshore, produced-water discharges conducted by the Offshore Operators Committee (Ray, 1998) assessed that metals discharged in produced water would, at worst, affect living organisms found in the immediate vicinity of the discharge, particularly those attached to the submerged portion of platforms. Possibly toxic concentrations of produced water were reported 20 m (66 ft) from the discharge in both the sediment and the water column where elevated levels of hydrocarbons, lead, and barium occurred, but no impacts to marine organisms or sediment contamination were reported beyond 100 m (328 ft) of the discharge (Neff and Sauer, 1991; Trefry et al., 1995). A study conducted on two species of mollusk and five species of fish (Ray, 1998) found that naturally occurring radioactive material in produced water was not found to bioaccumulate in marine animals. Because high-molecular PAH's are usually in such dilute concentrations in produced water, they pose little threat to marine organisms and their constituents, and they were not anticipated to biomagnify in marine food webs. Monocyclic hydrocarbons and other miscellaneous organic chemicals are known to be moderately toxic, but they do not bioaccumulate to high concentrations in marine organisms and are not known to pose a risk to their consumers (Ray, 1998).

Produced waters should not impact to the biota of topographic features. The greatest impacts are reported adjacent to the discharge and substantially reduced less than 100 m (328 ft) from the discharge, which is less than the 152-m (500-ft) buffer around the No Activity Zone that surrounds topographic features. Also, USEPA's general NPDES permit restrictions on the discharge of produced water would help to limit the impacts on biological resources of topographic features.

Structure-Removal Impacts

The impacts of structure removal on soft-bottom benthic communities can include turbidity, sediment deposition, explosive shock-wave impacts, and loss of habitat. Both explosive and nonexplosive removal operations would disturb the seafloor by generating considerable turbidity. Suspended sediment may evoke physiological impacts in benthic organisms, including changes in respiration rate, abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus (Anchor Environmental CA, L.P., 2003) and reduced photosynthesis (Rogers, 1990). Long-term exposures to turbidity have even resulted in significantly reduced skeletal extension rates in the scleractinian coral *Montastraea annularis* (Torres, 2001). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, reducing light intensity, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced coverage, changes in species diversity and dominance patterns, alterations in growth rates and forms, decreased calcification, decreased photosynthesis, increased respiration, increased production in mucus, loss of zooxanthellae, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Scleractinian corals are tolerant of short-term sediment exposure and burial, but longer exposures may result in loss of zooxanthellae, polyp swelling, increased mucus production, reduced coral growth, and reduced reef development (Marszalek, 1981; Rice and Hunter, 1992). Bleached tissue as a result of sediment exposure has been reported to recover in approximately a month (Wesseling et al., 1999).

Octocorals and gorgonians are more tolerant of sediment deposition than scleractinian corals, as they grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992b). Branching forms of scleractinian corals also tend to be more tolerant of sediment deposition than massive and encrusting forms (Roy and Smith, 1971). Some of the more sediment-tolerant scleractinian species in the Gulf of Mexico include *Montastraea cavernosa*, *Siderastrea siderea*, *Siderastrea radians*, and *Diploria strigosa* (Torres et al., 2001; Acevedo et al., 1989; Loya, 1976b).

The shock waves produced by the explosive structure removals may also harm benthic biota. However, corals and other sessile invertebrates have a high resistance to shock. O'Keeffe and Young (1984) described the impacts of underwater explosions on various forms of sea life using, for the most part, open-water explosions much larger than those used in typical structure-removal operations. They found that sessile benthic organisms, such as barnacles and oysters, and many motile forms of life, such as shrimp and crabs (that do not possess swim bladders), were remarkably resistant to shock waves generated by underwater explosions. Oysters located 8 m (26 ft) away from the detonation of 135-kilogram (kg) (298-pound [lb]) charges in open water incurred a 5-percent mortality rate. Crabs distanced 8 m (26 ft) away from the explosion of 14-kg (31-lb) charges in open water had a 90-percent mortality rate. Few crabs died when the charges were detonated 46 m (151 ft) away. O'Keeffe and Young (1984) also described lack of damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods.

Charges used in OCS structure removals are typically much smaller than some of those cited by O'Keeffe and Young. The *Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf: Programmatic Environmental Assessment* (USDOI, MMS, 2005) predicts low impacts on the sensitive offshore habitats from platform removal precisely because of the effectiveness of the proposed stipulation in preventing platform emplacement in the most sensitive areas of the topographic features of the GOM. Impacts on the biotic communities, other than those on or directly associated with the platform, would be limited by the relatively small size of individual charges (normally 50 lb [27 kg] or less per well piling and per conductor jacket) and because BOEMRE regulations require charges to be detonated 5 m (15 ft) below the mudline and at least 0.9 seconds apart (to prevent shock waves from becoming additive) (USDOI, MMS, 2005). Also, because the proposed Topographic Features Stipulation precludes platform installation within 152 m (500 ft) of a No Activity Zone, adverse effects to topographic features by removal explosives should be prevented. The shock wave is significantly attenuated when explosives are buried, as opposed to detonation in the water column (Baxter et al., 1982; Wright and Hopky, 1998).

Removal of infrastructure would result in the removal of the hard substrate and encrusting community, with overall reduction in species diversity (both epifaunal encrusting organisms and the fish and large invertebrates that fed on them) with the removal of the structure (Schroeder and Love, 2004). The removal of a platform may extract a viable habitat utilized during cross pollination with a topographic feature and supported viable finfish communities. The epifaunal organisms attached to the platform that are physically removed would die once the platform is removed and disposed of. However, the seafloor habitat would return to the original soft-bottom substrate that existed before the well was drilled.

Some structures may be converted to artificial reefs. If the rig stays in place, the hard substrate and encrusting communities would remain part of the benthic habitat. The diversity of the community would not change, and associated finfish species would continue to graze on the encrusting organisms. The community would remain an active artificial reef. However, the plugging of wells and other reef in place decommissioning activities would still impact benthic communities as discussed above.

Proposed Action Analysis

Of 16 topographic features (shelf-edge banks, mid-shelf banks, and low-relief banks) in the CPA, 15 are found in waters less than 200 m (656 ft) deep. Geyer Bank is located at a depth of 190-210 m (623-689 ft). They represent a small fraction of the CPA. As noted above, the proposed Topographic Features Stipulation could prevent most of the potential impacts from oil and gas operations on the biota of topographic features, including direct contact during pipeline, rig, and platform emplacements; anchoring activities, and removals. Yet, operations outside the No Activity Zone could still affect topographic features through drilling effluent discharges and produced-water discharges, blowouts, and oil spills. Potential impacts from oil spills and blowouts are discussed in **Chapter 4.1.1.7.3.**

For the CPA proposed action, 17-23 exploration/and 62-85 development wells are projected for offshore Subarea W0-60. There are an additional 9-14 exploration/delineation wells and 23-33 development wells proposed between 60 and 200 m (197 and 656 ft) (the boundary of the continental shelf) (**Table 3-2**). With the inclusion of the proposed Topographic Features Stipulation, no discharges would take place within the No Activity Zone. Most drilling discharges would be shunted to within 10 m (33 ft) of the seafloor either within the 1,000-Meter Zone, 1-Mile Zone, 3-Mile Zone, or 4-Mile Zone

(depending on the topographic feature) around the No Activity Zone (see **Chapter 2.3.1.3.1** for specifics). This procedure would essentially prevent the threat of large amounts of drilling effluents reaching the biota of a given topographic feature. Also, most studies indicate that biological impacts and sediment contamination occur within 100 m (328 ft) of production platforms (Montagna and Harper, 1996; Kennicutt at al., 1996; Neff and Sauer, 1991; Trefry et al., 1995). If drilling effluents or produced waters do reach any topographic features, concentrations of these anthropogenic influences should be diluted substantially from their initial concentration, and effects would be minimal.

For the CPA proposed action, 20-25 production structures are projected in offshore Subarea W0-60 and 2-3 production structures are predicted for Subarea W60-200. From 14 to 17 structure removals using explosives are projected for the Subarea W0-60 and 2 are projected in Subarea W60-200. The explosive removal of platforms should not impact the biota of topographic features because the proposed Topographic Features Stipulation prohibits the emplacement of platforms within 152 m (500 ft) of the No Activity Zone boundaries. This emplacement would prevent shock-wave impacts and resuspended sediments from reaching the biota of topographic features. Site clearance operations following a structure removal typically employ trawling the sea bottom within a radius of up to 400 m (1,320 ft) to retrieve anthropogenic debris. In areas near sensitive habitats, operators may be required to use sonar to detect debris and scuba divers to retrieve it. This precaution is exercised by BOEMRE as needed in the activity permitting process.

Summary and Conclusion

The proposed Topographic Features Stipulation would prevent most of the potential impacts on topographic features from bottom-disturbing activities (structure removal and emplacement) and operational discharges associated with the CPA proposed action. Because of the No Activity Zone, permit restrictions, and the high-energy environment associated with topographic features, if any contaminants reach topographic features they would be diluted from their original concentration and impacts that do occur would be minimal.

Effects of the Proposed Action without the Proposed Stipulation

The topographic features and associated coral reef biota of the CPA could be adversely impacted by oil and gas activities resulting from the proposed action in the absence of the proposed Topographic Features Stipulation. This would be particularly true should operations occur directly on top of or in the immediate vicinity of otherwise protected CPA topographic features.

The No Activity Zone of the topographic features would be most susceptible to adverse impacts if oil and gas activities are unrestricted without the proposed Topographic Feature Stipulation. These impacting activities could include vessel anchoring and infrastructure emplacement; discharges of drilling muds, cuttings, and produced water; and ultimately the explosive removal of structures. All the above-listed activities have the potential to considerably alter the diversity, cover, and long-term viability of the reef biota found within the No Activity Zone. In most cases, recovery from disturbances would take 10 years or more (Fucik et al., 1984; Rogers and Garrison, 2001). Long-lasting and possibly irreversible change would be caused mainly by vessel anchoring and structure emplacement (pipelines, drill rigs, and platforms). Such activities would physically and mechanically alter benthic substrates and their associated biota. Operational discharges would cause substantial and prolonged turbidity and sedimentation, possibly impeding the well-being and permanence of the biota and interfering with larval settlement, resulting in the decrease of live benthic cover. Finally, the unrestricted use of explosives to remove platforms installed in the vicinity of or on the topographic features could cause turbidity, sedimentation, and shock-wave impacts that would affect reef biota.

The shunting of cuttings and fluids, which would be required by the proposed Topographic Features Stipulation, is intended to limit the smothering and crushing of sensitive benthic organisms caused by depositing foreign substances onto the topographic features. The impacts from unshunted exploration and development discharges of drill cuttings and drilling fluids within the 1,000-Meter Zone, 1-Mile Zone, and 4-Mile Zone would definitely impact the biota of topographic features. Specifically, the discharged materials would cause prolonged events of turbidity and sedimentation, which could have long-term deleterious effects on local primary production, predation, and consumption by benthic and pelagic organisms, biological diversity, and benthic live cover. The unrestricted discharge of drilling cuttings and

fluids during development operations would be a further source of impact to the sensitive biological resources of the topographic features. Therefore, in the absence of the proposed Topographic Features Stipulation, the proposed action could cause long-term (10 years or more) adverse impacts to the biota of the topographic features (Fucik et al., 1984; Rogers and Garrison, 2001).

4.1.1.7.3. Impacts of Accidental Events

The topographic features of the CPA that sustain sensitive offshore habitats are listed and described in **Chapter 4.1.1.6.1**. See **Chapter 2.4.1.3.1** for a complete description and discussion of the proposed Topographic Features Stipulation.

Disturbances resulting from the CPA proposed action, including oil spills and blowouts, have the potential to disrupt and alter the environmental, commercial, recreational, and aesthetic values of topographic features of the CPA.

A search was conducted for additional new information published since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. Various Internet sources and journal articles were examined to discover any recent information regarding impacts of oil on benthic organisms. Sources investigated include literature published in journals and websites (NOAA, USEPA, and coastal universities). The following information is a summary of the accidental impacts incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Possible Modes of Exposure

Oil released to the environment as a result of an accidental event may impact topographic features in several ways. Oil may be physically mixed into the water column from the sea surface, be injected below the sea surface and travel with currents, be dispersed in the water column, or be adsorbed to sediment particles and sink to the seafloor. These scenarios and their possible impacts are discussed in the following sections.

An oil spill that occurs at the sea surface would result in a majority of the oil remaining at the sea surface. Lighter compounds in the oil may evaporate, and some components of the oil may dissolve in the seawater. Evaporation allows the removal of the most toxic components of the oil, while dissolution may allow bioavailability of hydrocarbons to marine organisms for a brief period of time (Lewis and Aurand, 1997). Remnants of the oil may then emulsify with water or adsorb to sediment particles and fall to the seafloor.

A spill that occurs below the sea surface (i.e., at the rig, along the riser between the seafloor and sea surface, or through leak paths on the BOP/wellhead) would result in most of the released oil rising to the sea surface. All known reserves in the Gulf of Mexico have specific gravity characteristics that would preclude oil from sinking immediately after release at a blowout site. As discussed in Chapter 4.3.1.5.4 of the Multisale EIS, oil discharges that occur at the seafloor from a pipeline or loss of well control would rise in the water column, surfacing almost directly over the source location, thus not impacting sensitive deepwater communities. If the leak is deep in the water column and the oil is ejected under pressure, oil droplets may become entrained deep in the water column (Boehm and Fiest, 1982). The upward movement of the oil may be reduced if methane in the oil is dissolved at the high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). The large oil droplets would rise to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume or the injection of dispersants, may remain neutrally buoyant in the water column, creating a subsurface plume (Adcroft et al., 2010). Oil droplets less than 100 μm in diameter may remain in the water column for several months (Joint Analysis Group, 2010a). Dispersed oil in the water column begins to biodegrade and may flocculate with particulate matter, promoting sinking of the particles.

Impacts that may occur to benthic communities on topographic features as a result of a spill would depend on the type of spill, distance from the spill, relief of the biological feature, and surrounding physical characteristics of the environment (e.g., turbidity). The NTL 2009-G39 describes the proposed Topographic Features Stipulation, which requires buffers to prevent oil spills in the immediate vicinity of a topographic feature or its associated biota. The BOEMRE has created No Activity Zones around topographic features in order to protect these habitats from disruption due to oil and gas activities. A No Activity Zone is a protective perimeter drawn around each feature that is associated with a specific

isobath (depth contour) surrounding the feature in which structures, drilling rigs, pipelines, and anchoring are not allowed. These No Activity Zones are areas protected by BOEMRE policy. The NTL 2009-G39 recommends that drilling not occur within 152 m (500 ft) of a No Activity Zone of a topographic feature. This additional recommendation is based on essential fish habitat, and construction within the essential fish habitat would require project-specific consultation with NOAA.

Oil released during accidental events may reach topographic features. As described above, most of the oil released from a spill would rise to the sea surface and therefore reduce the amount of oil that may directly contact benthic communities. Small droplets of oil in the water column could possibly migrate into No Activity Zones, attach to suspended particles in the water column, and sink to the seafloor (McAuliffe et al., 1975). Topographic features and their benthic communities that are exposed to subsea plumes, dispersed oil, or oil adsorbed to sediment particles may demonstrate reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. These impacts are discussed in the following sections.

Surface Slicks and Physical Mixing

The potential of surface oil slicks to affect topographic features is limited by its ability to mix into the water column. Topographic features are high-relief protrusions above the seafloor on the continental shelf; the shallowest peaks rise to within 15 m (49 ft) of the sea surface. The two peaks of the Flower Garden Banks are the shallowest and most sensitive features, supporting true coral reefs. Other banks are deeper, supporting reef communities but not coral reefs (**Chapter 4.1.1.7.1**). The depth of the topographic features below the sea surface helps protect benthic species from physical oil contact through distance below the sea surface.

Field data collected at the Atlantic entrance to the Panama Canal 2 months after a tanker spill has shown that subtidal coral species (i.e., *Porites furcata*, *Porites asteroids*, *Siderastrea radians*, and *Millepora complanata*), all of which are also present in the Gulf of Mexico, did not show measurable impacts from the oil spill, presumably because the coral was far enough below the surface oil and the oil did not contact the coral (Rützler and Sterrer, 1970). Similar results were reported from a Florida coral reef immediately following and 6 months after a tanker discharged oil nearby (Chan, 1977). The lack of acute toxicity was again attributed to the fact that the corals were completely submerged at the time of the spill and calm conditions prevented the oil from mixing into the water column (Chan, 1977).

Disturbance of the sea surface by storms can mix surface oil into the water column, but the effects are generally limited to the upper 10 m (33 ft). Modeling exercises have indicated that oil may reach a depth of 20 m (66 ft). Yet at this depth, the spilled oil would be at concentrations several orders of magnitude lower than the amount shown to have an effect on marine organisms (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Therefore, depth may contribute to the protection of topographic features from physical mixing of surface oil below the sea surface. However, if dispersants are used, they would enable oil to mix into the water column and possibly impact organisms on the topographic features. Dispersants are discussed later in this section.

Subsurface Plumes

A subsurface oil spill or plume has the potential to reach a topographic feature and cause negative effects. Such impacts on the biota may have severe and long-lasting consequences, including loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success.

Topographic features are sheltered from petroleum-producing activities through the distance provided from No Activity Zone and the NTL 2009-G39 recommendation of the additional 152-m (500-ft) buffer beyond the No Activity Zone. The distance allows for several physical and biological changes to occur to the oil before it reaches sensitive benthic organisms. Oil would become diluted as it physically mixes with the surrounding water, and some evaporation may occur. The longer and farther a subsea plume travels in the sea, the more dilute the oil will be (Vandermeulen, 1982; Tkalich and Chan, 2002). Microbial degradation of the oil occurs in the water column, reducing toxicity (Hazen et al., 2010; McAuliffe et al., 1981b). In addition, oil can adsorb to sediments in the water column and sink to the seafloor. The oil will move in the direction of prevailing currents (S.L. Ross Environmental Research Ltd., 1997); however, the banks will be physically protected because currents move around the topographic features, which may help sweep the subsea oil clear of the banks (Rezak et al., 1978; Rezak

et al., 1983; McGrail, 1982). Also, subsea oil plumes transported by currents may not travel nearly as far as surface oil slicks because some oil droplets may conglomerate and rise or may be blocked by fronts, as was observed in the southern Gulf of Mexico during the *Ixtoc I* spill (Boehm and Fiest, 1982). Should any of the oil come in contact with adult sessile biota, effects would be primarily sublethal, as the oil would be diluted by physical and biological processes by the time it reaches the banks. Low-level exposure impacts may vary from chronic to temporary, or even immeasurable.

In the event that low concentrations of oil transported in subsea plumes reaches benthic features, coral feeding activity may be reduced. Experiments indicated that normal feeding activity of *Porites porites* and *Madracis asperula* were reduced when exposed to 50 ppm oil (Lewis, 1971). Tentacle pulsation of an octocoral, *Heteroxenia fuscescens*, has also been shown to decrease upon oil exposure, although recovery of normal pulsation was observed 96 hours after the coral was removed from the oil (Cohen et al., 1977). *Porites furcata* exposed to marine diesel and Bunker C oil reduced feeding and left their mouths open for longer than normal periods of time (Reimer, 1975).

Direct oil contact may result in coral tissue damage. Coral exposed to sublethal concentrations of oil for 3 months revealed atrophy of muscle bundles and mucus cells (Peters et al., 1981). *Porites furcata* submersed in Bunker C oil for 1 minute resulted in 100 percent tissue death (with a lag time of 114 days) (Reimer, 1975).

Reproductive ability may also be reduced if coral is exposed to oil. A hermatypic coral, *Stylophora pistillata*, and an octocoral, *Heteroxenia fuscescens*, shed their larvae when exposed to oil (Loya and Rinkevich, 1979; Rinkevich and Loya, 1977; Cohen et al., 1977). Neither of these species is present in the Gulf of Mexico, but impacts may be similar in Gulf species. Undeveloped larvae exposed to oil in the water column have a reduced chance of survival due to predation (Loya and Rinkevich, 1979), which would in turn reduce the ability of larval settlement and reef expansion or recovery. A similar expulsion of gametes may occur in species that have external fertilization (Loya and Rinkevich, 1979), such as those at the Flower Garden Banks in the WPA (Gittings et al., 1992c), which may then reduce gamete survivorship due to oil exposure.

The overall ability of a coral colony to reproduce may be affected by oil exposure. Reefs of *Siderastrea siderea* that were oiled in a spill produced smaller gonads than unoiled reefs, which resulted in reproductive stress for the oiled reef (Guzmán and Holst, 1993). *Stylophora pistillata* reefs exposed to oil had fewer breeding colonies, reduced number of ovaries per polyp, and significantly reduced fecundity compared with unoiled reefs (Rinkevich and Loya, 1977). Impaired development of reproductive tissue has been reported for other reef-building corals exposed to sublethal concentrations of oil as well (Peters et al., 1981). Larvae also may not be able to settle on reefs impacted by oil. Field experiments on *Stylophora pistillata* showed reduced settlement rates of larvae on artificial substrates of oiled reefs compared with control reefs and lower settlement rates with increasing concentrations of oil in test containers (Rinkevich and Loya, 1977).

Oil exposure is believed to reduce photosynthesis and growth in corals; however, low-level exposures have produced counterintuitive and sometimes immeasurable results. Photosynthesis of the zooxanthellae in *Diploria strigosa* exposed to approximately 18-20 ppm crude oil for 8 hours was not measurably affected, although other experiments indicate that photosynthesis may be impaired at higher concentrations (Cook and Knap, 1983). A longer exposure (24 hours) of 20 mL/L (20 ppt) oil markedly reduced photosynthesis in *Stylophora pistillata*; however, concentrations of 2.5 mL/L (2.5 ppt) oil resulted in physiological stress that caused a measurable increase in photosynthesis as compared with controls (Rinkevich and Loya, 1983). Other impacts recorded include the degeneration and expulsion of photosynthetic zooxanthellae upon coral exposure to oil (Loya and Rinkevich, 1979; Peters et al., 1981). Long-term growth changes in *Diploria strigosa* that was exposed to oil concentrations up to 50 ppm for 6-24 hours did not show any measurably reduced growth in the following year (Dodge et al., 1984).

Corals exposed to subsea oil plumes may also incorporate petroleum hydrocarbons into their tissue. Records indicate that *Siderastrea siderea*, *Diploria strigosa*, *Montastraea annularis*, and *Heteroxenia fuscescens* have accumulated oil from the water column and have incorporated petroleum hydrocarbons into their tissues (Burns and Knap, 1989; Knap et al., 1982; Kennedy et al., 1992; Cohen et al., 1977). Hydrocarbon uptake may also modify lipid ratios of coral (Burns and Knap, 1989). If lipid ratios are modified, mucus synthesis may be impacted, adversely affecting coral ability to protect itself from oil through mucus production (Burns and Knap, 1989).

Sublethal effects, although often hard to measure, could be long lasting and affect the resilience of coral colonies to natural disturbances (e.g., elevated water temperature, extreme low tides, and diseases) (Jackson et al., 1989; Loya, 1976a). Continued exposure to oil from resuspended contaminated sediments in the area could also impact coral growth and recovery (Guzmán et al., 1994). Any repetitive or long-term oil exposure could inhibit coral larvae's ability to settle and grow, may damage coral reproductive systems, may cause acute toxicity to larvae, and may physically alter the reef interfering with larval settlement, all of which would reduce coral recruitment to an impacted area (Kushmaro et al., 1997; Loya, 1975 and 1976a; Rinkevich and Loya, 1977). Exposure of eggs and larvae to oil in the water column may reduce the success of a spawning event (Peters et al., 1997). Sublethal exposure to oil may in fact be more detrimental to corals than high concentrations of oil (Cohen et al., 1977), as sublethal concentrations are typically more widespread and have a larger overall community effect. Therefore, the sublethal effects of oil exposure, even at low concentrations, may have long-lasting effects on the community.

The NTL 2009-G39 protects topographic features from both routine and accidental impacts that may occur during petroleum production; however, recent reports have indicated damage to a deepwater coral community that appeared to be impacted by contact with oil resulting from the DWH event; this community is far deeper than the reef organisms on the topographic features (USDOI, BOEMRE, 2010i). The circumstances of the deepwater coral exposure were not typical because the release of oil was 1,500 m (4,921 ft) below the sea surface at high pressure, which caused the formation of a subsea plume of oil that was treated with dispersant, allowing it to remain at a water depth between 1,100 and 1,300 m (3,609 and 4,265 ft) (Joint Analysis Group, 2010a). This 200-m (656-ft) thick subsea plume was in deep water and was thought to be bounded by stratified density layers of water, allowing it to remain at depth instead of dispersing into the water column and to eventually contact the coral. Such an occurrence should not occur on the continental shelf where the topographic features are found because, even though stratified waters called the nepheloid layer (a layer of turbid water) are found on the continental shelf, studies show that stratified water normally restricts the nepheloid layer to near the seafloor; that is, no more than 20 m (66 ft) up into the water column (Bright et al., 1976; Bright and Rezak, 1978). Therefore, while stratified layers in deep water may cover 200 m (656 ft) of depth, layers on the shelf would have a smaller range and oil trapped in the bottom layer would be restricted to less than 20 m (66 ft) above the seafloor. The reef organisms of the topographic features live above the turbid waters and, therefore, they could not be contacted by stratified oil later. Also, currents around the topographic features may sweep the subsea oil clear of the features, as bottom currents typically travel around topographic highs rather than over them (Rezak et al., 1983).

Dispersed Oil

Chemically dispersed oil from a surface slick is not anticipated to result in lethal exposures to organisms on topographic features. The chemical dispersion of oil may increase the weathering process and allow surface oil to penetrate to greater depths than physical mixing would permit, and the dispersed oil generally remains below the water's surface (McAuliffe et al., 1981b; Lewis and Aurand, 1997). However, reports on dispersant usage on surface plumes indicate that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to stick to particles in the water column, minimizing oil adsorbed to sediment particles traveling to the seafloor (McAuliffe et al., 1981a; Lewis and Aurand, 1997).

Field experiments designed to test dispersant use on oil spills reported dispersed oil concentrations between 1 and 3 ppm, 9 m (26 ft) below the sea surface, approximately 1 hour after treatment with dispersant (McAuliffe et al., 1981a and 1981b). Other studies indicated that dispersed oil concentrations were <1 ppm, 10 m (33 ft) below the sea surface (Lewis and Aurand, 1997). The above data indicate that the mixing depth of dispersed oil is less than the depths of the crests of topographic features (greater than 15 m [49 ft] below the sea surface), greatly reducing the possibility of exposure to dispersed surface oil.

Any dispersed surface oil that may reach the benthic communities of topographic features in the Gulf of Mexico would be expected to be at very low concentrations (<1 ppm) (McAuliffe et al., 1981a). Such concentrations would not be life threatening to larval or adult stages, based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed oil in

the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms, such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

The use of dispersants near or above protected features, such as the Flower Garden Banks, is not recommended because dispersants allow floating oil to mix with water. The Flower Garden Banks National Marine Sanctuary helped to develop a regional response plan for dispersant use near the sanctuary using literature, field observations, and spill risk assessments (Gittings, 2006). Results of the investigations led to a NOAA policy revision in 1994 that allowed dispersant use if the Federal On-Scene Coordinator deems it appropriate, but the Flower Garden Banks National Marine Sanctuary requests that dispersant application be as far as possible from the sanctuary and not occur during seasonal species gatherings or spawning. Also, the Sanctuary's management must be consulted and forwarded incident relevant data (Gittings, 2006). The distancing of the dispersant application from the Flower Garden Banks National Marine Sanctuary would allow for dilution of the compounds in the surrounding water column away from protected habitat.

Dispersants that are used on oil below the sea surface can travel with currents through the water and may contact benthic organisms on the topographic features. If the oil spill occurs near a topographic feature, the dispersed oil could be concentrated enough to harm the community. However, the longer the oil remains suspended in the water column traveling with currents, the more dispersed it would become. Weathering will also be accelerated and biological toxicity reduced (McAuliffe et al., 1981b). Although the use of subsea dispersants is a new technique and very little data are available on dispersion rates, it is anticipated that any oil that could reach topographic features will be in low concentration based on surface slick dilution data (McAuliffe et al., 1981a; Lewis and Aurand, 1997). Currents around the topographic features may sweep the subsea oil clear of the features, as bottom currents typically travel around topographic highs rather than over them (Rezak et al., 1983). Recent data from studies of the DWH event and resulting spill showed that oil treated with dispersant at depth remained at a water depth between 1,100 and 1,300 m (3,600 and 4,265 ft) (Joint Analysis Group, 2010a). This subsea plume was in deep water rather than on the continental shelf. While the DWH event's subsea oil plume ranged through a 200-m (656-ft) depth range, it was thought to be bounded by stratified density layers of water. Stratification is also found on the continental shelf. Studies of the nepheloid layer (a layer of turbid water) showed that stratified water normally restricts the nepheloid layer to near the seafloor, no more than 20 m (66 ft) up into the water column (Bright et al., 1976; Bright and Rezak, 1978). So, while stratified layers in deep water may cover 200 m (656 ft) of depth, layers on the shelf have a smaller range and oil trapped in the bottom layer may be restricted to less than 20 m (66 ft) above the seafloor. Unusual circumstances, such as mixing resulting from passage of a hurricane, may change this situation somewhat, causing subsea oil plumes to mix through the entire water column. However, such mixing would also serve to reduce the concentration of toxic components. Therefore, impacts resulting from exposure to dispersed oil are anticipated to be sublethal for communities on topographic features. In some cases, less diverse communities at the base of topographic features could experience lethal contact with subsea oil plumes if the source of the spill is nearby on the seafloor.

Sublethal impacts that may occur to coral exposed to dispersed oil may include reduced feeding and photosynthesis, reduced reproduction and growth, physical tissue damage, and altered behavior. Short-term, sublethal responses of *Diploria strigosa* were reported after exposure to dispersed oil at a concentration of 20 ppm for 24 hours (Knap et al., 1983; Wyers et al., 1986). Although concentrations in this experiment were higher than what is anticipated for dispersed oil at depth, effects included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction, localized tissue rupture (Wyers et al., 1986), and a decline in tentacle expansion behavior (Knap et al., 1983). Normal behavior resumed within 2 hours to 7 days after exposure (Wyers et al., 1986; Knap et al., 1983). This coral, however, did not show indications of stress when exposed to 1 ppm and 5 ppm of dispersed oil for 24 hours (Wyers et al., 1986). *Diploria strigosa* exposed to dispersed oil (20:1, oil:dispersant) showed an 85 percent reduction in zooxanthellae photosynthesis after 8 hours of exposure to the mixture (Cook and Knap, 1983). However, the response was short-term, as recovery occurred between 5 and 24 hours after exposure and return to clean seawater. Investigations 1 year after *Diploria strigosa* was exposed to concentrations of dispersed oil between 1 and 50 ppm for periods between 6 and 24 hours did not reveal any impacts to growth (Dodge et al., 1984; Knap et al., 1983). It should be noted, however, that subtle growth effects may have occurred but were not measurable (Knap et al., 1983).

Historical studies indicate that dispersed oil does appear to be more toxic to coral species than oil or dispersant alone. The greater toxicity may be a result of an increased number of oil droplets, resulting in a greater contact area between the dispersed oil and water (Elgershuizen and De Kruijf, 1976). The dispersant results in a higher water-soluble fraction of oil contacting the cell membranes of the coral (Elgershuizen and De Kruijf, 1976). The mucus produced by coral, however, can protect an organism from oil. Both hard and soft corals have the ability to produce mucus, and mucus production has been shown to increase when corals are exposed to crude oil (Mitchell and Chet, 1975; Ducklow and Mitchell, 1979). Dispersed oil, which has very small oil droplets, does not appear to adhere to coral mucus, and larger untreated oil droplets may become trapped by the mucus barrier (Knap, 1987; Wyers et al., 1986). However, entrapment of the larger oil droplets may increase long-term exposure to oil if the mucus is not shed in a timely manner (Knap, 1987; Bak and Elgershuizen, 1976).

More recent field studies did not reveal as great an impact of dispersants on corals as were indicated in historical toxicity tests (Yender and Michel, 2010). This difference in reported damage probably resulted from a more realistic application of dispersants in an open field system and because newer dispersants are less toxic than the older ones (Yender and Michel, 2010). Field studies have shown oil to be dispersed to the part per billion level minutes to hours after the dispersant application, which is orders of magnitude below the reasonable effects threshold of oil in the water column (20 ppm) measured in some studies (McAuliffe, 1987; Shigenaka, 2001).

Although dispersed oil may be more toxic than untreated oil to corals during exposure experiments (Shafir et al., 2007; Wyers et al., 1986; Cook and Knap, 1983), untreated oil may remain in the ecosystem for long periods of time, while dispersed oil does not (Baca et al., 2005; Ward et al., 2003). Twenty years after an experimental oil spill in Panama, oil and impacts from untreated oil were still observed at oil treatment sites, but no oil or impacts were observed at dispersed oil or reference sites (Baca et al., 2005). Long-term recovery of the coral at the dispersed oil site had already occurred as reported in a 10-year monitoring update, and the site was not significantly different from the reference site (Ward et al., 2003).

The time of year and surrounding ecosystem must be considered when determining if dispersants should be used. Dispersant usage may result in reduced or shorter term impacts to coral reefs; however, it may increase the impacts to other communities, such as mangroves (Ward et al., 2003). Therefore, dispersant usage may be more applicable offshore than in coastal areas where other species may be impacted as well. In addition, dispersant use may be restricted in some areas during peak coral spawning periods (e.g., August-September for major reef-building species) (Gittings et al., 1992c and 1994) in order to limit the impacts of oil pollution on the near-surface portion of the water column.

Oil Adsorbed to Sediment Particles

Smaller suspended oil droplets could be carried to the seafloor as a result of oil droplets adhering to suspended particles in the water column. Smaller particles have a greater affinity for oil (Lewis and Aurand, 1997). Oil may also reach the seafloor through consumption by plankton with excretion distributed over the seafloor (ITOPF, 2007). Oiled sediment that settles to the seafloor may affect organisms attached to topographic features. It is anticipated that the greatest amount of oil adsorbed to sediment particles would occur close to the spill, with lesser concentrations farther from the source. Studies after a spill that occurred at the Chevron Main Pass Block 41C Platform in the northern Gulf of Mexico revealed that the highest concentrations of oil in the sediment were close to the platform and that the oil settled to the seafloor within 5-10 mi (8-16 km) of the spill site (McAuliffe et al., 1975). Therefore, if the spill occurs close to a topographic feature, the underlying benthic communities may become smothered by the particles and exposed to toxic hydrocarbons. However, because of the implementation of the No Activity Zone and surrounding 152-m (500-ft) buffer zone, topographic features should be distanced from the heaviest oiled sedimentation effects. Oiled sediment depositional impacts, however, are possible and may smother nearby benthic species.

Some oiled particles may become widely dispersed as they travel with currents while they settle out of suspension. Settling rates are determined by size and weight of the particle, salinity, and turbulent mixing in the area (Poirier and Thiel, 1941; Bassin and Ichiye, 1977; Deleersbijder et al., 2006). Because particles would have different sinking rates, the oiled particles would be dispersed over a large area, most likely at sublethal or immeasurable levels. Studies conducted after the *Ixtoc* oil spill revealed that although oil was measured on particles in the water column, measurable petroleum levels were not found

in the underlying sediment (ERCO, 1982). Based on BOEMRE's restrictions and the settling rates and behavior of oil attached to sediment particles, the majority of organisms that may be exposed to oil adsorbed to sediment particles are anticipated to experience low-level concentrations.

Some oil, however, could reach topographic features as particles with adhered oil settle out of the water column. Sublethal impacts to benthic organisms from such exposure may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. Experiments have shown that the presence of oil on available substrate for larval coral settlement has inhibited larval metamorphosis and larval settlement in the area (Kushmaro et al., 1997). Crude oil concentrations as low as 0.1 ppm on substrate upon which the coral larvae were to settle reduced larval metamorphosis occurrences by 50 percent after 8 days of exposure. Oil concentrations of 100 ppm on substrates resulted in only 3.3 percent of the test population metamorphosizing (Kushmaro et al., 1997). There were also an increased number of deformed polyps after metamorphosis due to oil exposure (Kushmaro et al., 1997). It is also possible that recurring exposure may occur if oil adsorbed to sediment particles is resuspended locally, possibly inhibiting coral growth and recovery in the affected areas (Guzmán et al., 1994). Oil stranded in sediment is reportedly persistent and does not weather much (Hua, 1999), so coral may be repeatedly exposed to low concentrations of oil.

Adult coral, however, may be able to protect itself from low concentrations of oil adsorbed to sediment particles by production and sloughing of mucus. Coral mucus may act as a barrier to protect coral from the oil in the water column, and it has been shown to aid in the removal of oiled sediment on coral surfaces (Bak and Elgershuizen, 1976). Corals may use a combination of increased mucus production and ciliary action to rid themselves of oiled sediment (Bak and Elgershuizen, 1976).

Blowout and Sedimentation

Oil or gas well blowouts are possible occurrences in the OCS. Benthic communities exposed to large amounts of resuspended sediments following a subsurface blowout could be subject to sediment suffocation, exposure to toxic contaminants, and reduced light. Should oil or condensate be present in the blowout flow, liquid hydrocarbons could be an added source of negative impact on the benthos.

Turbid waters have less light penetrating to depth, which may result in reduced photosynthesis by the symbiotic zooxanthellae that live in coral tissue (Rogers, 1990). Long-term exposures to turbidity have even resulted in significantly reduced skeletal extension rates in the scleractinian coral *Montastraea annularis* (Torres, 2001; Dodge et al., 1974) and an acute decrease in calcification rates of *Madracis mirabilis* and *Agaricia agaricites* (Bak, 1978). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact.

Suspended sediment that is transported by currents deep in the water column should not impact the benthic organisms on the upper portions of topographic features. Studies have shown that deep currents sweep around topographic features instead of over them, allowing the suspended sediment to remain at depth (Rezak et al., 1983; McGrail, 1982). Therefore, suspended sediment from depth should not be deposited on top of the elevated benthic organisms. Organisms on the lower levels around topographic features are frequently enveloped in a turbid nepheloid layer; organisms surviving here are tolerant of heavy turbidity.

Sediment that settles out of upper layers of the water column may impact benthic organisms of topographic features. Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, reducing light intensity, and causing physical abrasion (Wilber et al., 2005). Corals may experience reduced colony coverage, changes in species diversity and dominance patterns, alterations in growth rates and forms, decreased calcification, decreased photosynthesis, increased respiration, increased production in mucus, loss of zooxanthellae, lesions, reduced recruitment, and mortality (Torres et al., 2001; Telesnicki and Goldberg, 1995). Coral larvae settlement may also be inhibited in areas where sediment has covered available substrate (Rogers, 1990; Goh and Lee, 2008).

Impacts to corals as a result of sedimentation would vary based on coral species, the height to which the coral grows, degree of sedimentation, length of exposure, burial depth, and the coral's ability to clear the sediment. Impacts may range from sublethal effects such as reduced growth, alteration in form, reduced recruitment and productivity, and slower growth to death (Rogers, 1990).

Corals have some ability to rid themselves of sediment through mucus production and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995). Scleractinian corals are tolerant of short-term sediment exposure and burial, but longer exposures may result in loss of zooxanthellae, polyp swelling, increased mucus production, reduced coral growth, and reduced reef development (Marszalek, 1981; Rice and Hunter, 1992). Bleached tissue as a result of sediment exposure has been reported to recover in approximately a month (Wesseling et al., 1999).

Solitary octocorals and gorgonians, which are found on many hard-bottom features, are more tolerant of sediment deposition than colony-forming scleractinian corals because the solitary species grow erect and are flexible, reducing sediment accumulation and allowing easy removal (Marszalek, 1981; Torres et al., 2001; Gittings et al., 1992b). Branching and upright forms of scleractinian corals, such as *Madracis mirabilis* and *Agaricia agaricites*, also tend to be more tolerant of sediment deposition than massive, plating, and encrusting forms, such as *Porites astreoides* (Roy and Smith, 1971; Bak, 1978). Some of the more sediment tolerant scleractinian species in the Gulf of Mexico include *Montastraea cavernosa*, *Siderastrea siderea*, *Siderastrea radians*, and *Diploria strigosa* (Torres et al., 2001; Acevedo et al., 1989; Loya, 1976b).

Since the BOEMRE-proposed stipulation would preclude drilling within 152 m (500 ft) of the No Activity Zone, most adverse effects on topographic features from blowouts would be prevented. Petroleum-producing activities would be far enough removed that heavy layers of sediment that may become resuspended as a result of a blowout should settle out of the water column before they reach sensitive biological communities. Other particles that travel with currents should become dispersed as they travel, reducing turbidity or depositional impacts. Furthermore, sediment traveling at depth should remain at depth instead of rising to the top of topographic features.

Response Activity Impacts

Oil-spill-response activity may also affect sessile benthic communities on topographic features. Booms anchored to the seafloor are sometimes used to control the movement of oil at the water surface. Boom anchors can physically damage corals and other sessile benthic organisms, especially when booms are moved around by waves (Tokotch, 2010). Vessel anchorage and decontamination stations set up during response efforts may also break or kill hard-bottom features as a result of setting anchors. Spill response, especially in the case of a catastrophic spill, can involve activity by varied organizations, including many that are not coordinated by the oil-spill-response plan. While the spill-response plan and activities coordinated by responsible agencies such as NOAA and USCG would avoid damaging sensitive habitats, the risk remains that some other responders may not be aware of all the sensitive habitats of concern. Injury to coral reefs as a result of anchor contact may result in long-lasting damage or failed recovery (Rogers and Garrison, 2001). Effort should be made to keep vessel anchorage areas far from sensitive benthic features to minimize impact.

Drilling muds comprised primarily of barite may be pumped into a well to stop a blowout. If a “kill” is not successful, the mud may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath the extruded drilling mud would be buried. Based on the BOEMRE stipulation (NTL 2009-G39), a well should be far enough away from topographic features to prevent extruded drilling muds from smothering sensitive benthic communities. It is more likely that benthic organisms on topographic features would experience turbidity or light layers of sedimentation due to a blowout based on the BOEMRE stipulation. Turbidity impacts may result in reduced photosynthesis or growth (Rogers, 1990; Torres, 2001). Light layers of deposited sediment would most likely be removed by mucus and ciliary action (Marszalek, 1981; Bak and Elgershuizen, 1976; Telesnicki and Goldberg, 1995).

Proposed Topographic Features Stipulation

The proposed Topographic Features Stipulation would preclude drilling within 152 m (500 ft) of a No Activity Zone to prevent adverse effects from nearby drilling on topographic features. The BOEMRE has created a No Activity Zone around topographic features in order to protect these habitats from disruption due to oil and gas activities. A No Activity Zone is a protective perimeter drawn around each feature that is associated with a specific isobath (depth contour) surrounding the feature in which structures, drilling rigs, pipelines, and anchoring are not allowed. These No Activity Zones are areas protected by BOEMRE policy. The NTL 2009-G39 recommends that drilling would not occur within 152 m (500 ft) of a No

Activity Zone of a topographic feature. This additional recommendation is based on essential fish habitat, and construction within the essential fish habitat would require project-specific consultation with NOAA.

Although the BOEMRE's proposed stipulation prevents oil and gas drilling activity within 152 m (500 ft) of the No Activity Zone of topographic features, some sublethal effects may occur to benthic organisms as a result of an oil spill. Sublethal impacts may include exposure to low levels of oil, dispersed oil, oil adsorbed to sediment particles, and turbidity and sedimentation from disturbed sediments. Impacts from these exposures may include reduced photosynthesis, reduced growth, altered behavior, decreased community diversity, altered community composition, reduction in coral cover, and reduced reproductive success. The severity of these impacts may depend on the concentration and duration of exposure.

Proposed Action Analysis

All of the topographic features in the CPA are found in water depths less than 200 m (656 ft). They represent a small fraction of the continental shelf area in the CPA. The fact that the topographic features are widely dispersed, combined with the probable random nature of oil-spill locations, serves to limit the extent of damage from any given oil spill to the topographic features.

The proposed Topographic Features Stipulation (**Chapter 2.4.1.3.1**) would assist in preventing most of the potential impacts from oil and gas operations, including accidental oil spills and blowouts, on the biota of topographic features. However, operations outside the No Activity Zone (including blowouts and oil spills) may still affect topographic features.

The depth below the sea surface to which many topographic features rise helps to protect them from surface oil spills. Any oil that might be driven to 15 m (49 ft) or deeper would probably be at concentrations low enough to reduce impact to these features.

A subsurface spill or plume may impact sessile biota of topographic features. Oil or dispersed oil may cause sublethal impacts to benthic organisms if a plume reaches these features. Impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. The proposed Topographic Features Stipulation would limit the potential impact of such occurrences by keeping the sources of such adverse events geographically removed from the sensitive biological resources of topographic features.

Oil adsorbed to sediments or sedimentation as a result of a blowout may impact benthic organisms. However, the proposed Topographic Features Stipulation places petroleum-producing activity at a distance from topographic features, resulting in reduced turbidity and sedimentation, and any oil adsorbed to sediments should be well dispersed, resulting in a light layer of deposition that would be removed by the normal self-cleaning processes of benthic organisms.

Summary and Conclusion

The proposed Topographic Features Stipulation would assist in preventing most of the potential impacts on topographic feature communities from blowouts, surface, and subsurface oil spills and the associated effects by increasing the distance of such events from the topographic features. Any contact with spilled oil would likely cause sublethal effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. In the unlikely event that oil from a subsurface spill would reach the biota of a topographic feature, the effects would be primarily sublethal and impacts would be at the community level. Any turbidity, sedimentation, and oil adsorbed to sediments would also be at low concentrations by the time the topographic features were reached, also resulting in sublethal impacts. Impacts from an oil spill on topographic features are also lessened by the distance of the spill to the features, the depth of the features, and the currents that surround the features.

Effects of the Proposed Action without the Proposed Stipulation

The topographic features and associated coral reef biota of the CPA could be damaged by oil and gas activities resulting from the proposed action should they not be restricted by application of the proposed Topographic Features Stipulation. This would be particularly true should operations occur directly on top of or in the immediate vicinity of otherwise protected topographic features. The area within the No Activity Zone would probably be the areas of the topographic features that are most susceptible to adverse

impacts if oil and gas activities are unrestricted by the proposed Topographic Features Stipulation. These impacting factors would include blowouts, surface oil spills, and subsea oil spills. Potential impacts from routine activities resulting from the proposed action are discussed in **Chapter 4.1.1.7.2**.

Oil spills as well as routine activities have the potential to considerably alter the diversity, cover, and long-term viability of the reef biota found within the No Activity Zone if the proposed Topographic Features Stipulation is not applied. Direct oil contact may result in acute toxicity (Dodge et al., 1984; Wyers et al., 1986). In most cases, recovery from disturbances would take 10 years or more (Fucik et al., 1984; Rogers and Garrison, 2001). Indeed, disturbances, including oil spills and blowouts, would alter benthic substrates and their associated biota over large areas. In the unlikely event of a blowout, sediment resuspension potentially associated with oil could cause adverse turbidity and sedimentation conditions. In addition to affecting the live cover of a topographic feature, a blowout could alter the local benthic morphology, thus irreversibly altering the reef community. Oil spills (surface and subsea) could be harmful to the local biota should the oil have a prolonged or recurrent contact with the organisms. Therefore, in the absence of the proposed Topographic Features Stipulation, the proposed action could cause long-term (10 years or more) adverse impacts to the biota of the topographic features.

4.1.1.7.4. Cumulative Impacts

The proposed Topographic Features Stipulation is assumed to be in effect for this cumulative analysis. The continued application of this proposed stipulation would prevent any direct adverse impacts on the biota of the topographic features, i.e., impacts potentially generated by oil and gas operations. The cumulative impact from routine oil and gas operations includes effects resulting from the proposed action, as well as those resulting from past and future OCS leasing. These operations include anchoring, structure emplacement, muds and cuttings discharge, effluent discharge, blowouts, oil spills, and structure removal. Potential non-OCS-related factors include vessel anchoring, treasure-hunting activities, import tankering, heavy storms and hurricanes, the collapse of the tops of the topographic features due to dissolution of the underlying salt structure, commercial fishing, and recreational scuba diving.

Mechanical damage, including anchoring, is considered to be a catastrophic threat to the biota of topographic features. The proposed Topographic Features Stipulation prohibits oil and gas leaseholders from anchoring vessels and placing structures within 152 m (500 ft) of the No Activity Zone around topographic features (**Chapter 2.4.1.3.1**) (USDOI, MMS, 2009b); the stipulation does not affect other non-OCS activities such as anchoring, fishing, or recreational scuba diving, or anchoring other vessels on or near these features. Many of the topographic features are found near established shipping fairways and are well-known fishing areas. Also, several of the shallower topographic features are frequently visited by scuba divers aboard recreational vessels (Hickerson et al., 2008). Anchoring at a topographic feature by a vessel involved in any of these activities could damage the biota. The degree of damage would depend on the size of the anchor and chain (Lissner et al., 1991). Anchor damages incurred by benthic organisms may take more than 10 years to recover, depending on the extent of the damage (Fucik et al., 1984; Rogers and Garrison, 2001).

The use of explosives in treasure-hunting operations has become a concern on topographic features; several large holes and damage have occurred on Bright Bank. The blasting of large areas of Bright Bank by treasure hunters has resulted in the loss of extensive live coral cover (Schmahl and Hickerson, 2006). Treasure hunters have damaged the bank as recently as 2001 (Schmahl and Hickerson, 2006). The recovery from such destructive activity may take in excess of 10 years (Fucik et al., 1984; Rogers and Garrison, 2001). Recovery of the system to pre-interference conditions would depend on the type and extent of damage incurred by individual structures.

Impacts from natural occurrences such as hurricanes occasionally result in damage to the biota of the topographic features. Hurricane Rita caused severe damage to Sonnier Bank (Robbart et al., 2009). Live cover was reduced at this bank and the disappearance of the sponge colonies, *Xestospongia muta*, was notable (Robbart et al., 2009). The community structure had visibly changed from pre-Rita (2004) studies at this bank (Kraus et al., 2006 and 2007). In 2006, the habitat was dominated by algae, indicating an alteration in habitat after Hurricane Rita (Kraus et al., 2007). The algal cover, however, was the beginning of recovery of the storm-impacted areas, which was farther colonized with sponges (Robbart et al., 2009). Fish community shifts were also observed on Sonnier Bank after Hurricane Rita versus before the storm, but clear links have yet to be made to the storm (Kraus et al., 2007). Hurricane Katrina may

have caused similar damage on other topographic features. Another possible natural impact to the banks would be the dissolution of the underlying salt structure, leading to collapse of the reef (Seni and Jackson, 1983). Dissolution of these salt structures is unlikely and beyond regulation abilities.

Depending on the levels of fishing pressure exerted, fishing activities that occur at the topographic features may impact local fish populations. The collecting activities by scuba divers on shallow topographic features may have an adverse impact on the local biota. Anchoring during recreational and fishing activities, however, would be the source of the majority of severe impacts incurred by the topographic features.

The continued application of the proposed Topographic Features Stipulation precludes anchoring on topographic features by oil- and gas-related operations. Detrimental impacts would result if oil and gas operators anchored pipeline barges, drilling rigs, and service vessels or if they placed structures on topographic features (Rezak and Bright, 1979; Rezak et al., 1985). The Topographic Features Stipulation restricts these activities within 152 m (500 ft) of the No Activity Zone around topographic features, thus preventing adverse impacts on benthic communities of topographic communities (USDOI, MMS, 2009b).

The routine discharge of drilling muds and cuttings is restricted in the vicinity of topographic features. It is estimated that approximately 2,000 metric tons (2,205 tons) are discharged for exploratory wells (900 metric tons [992 tons] of drilling fluid and 1,100 metric tons [1,213 tons] of cuttings) and slightly lower discharges for development wells (Neff, 2005). Continued application of the Topographic Features Stipulation would require lease operators to comply with measures, such as shunting that would keep discharged materials at depths below sensitive biota.

The USEPA, through its NPDES discharge permit, also enacts further mitigating measures on discharges. As noted in **Chapter 4.1.1.7.2** above, drilling fluids can be moderately toxic to marine organisms (the more toxic effluents are not allowed to be discharged under NPDES permits), and their effects are restricted to areas closest to the discharge point, thus preventing contact with the biota of topographic features (Montagna and Harper, 1996; Kennicutt et al., 1996). Small amounts of drilling effluent in low concentrations may reach a bank from wells outside the No Activity Zone; however, these amounts, if measurable, would be extremely small and would be restricted to small areas with little effects on the biota.

The proposed Topographic Features Stipulation would protect topographic features by mandating a physical distance from drilling activities. Drilling fluid plumes are rapidly dispersed on the OCS; approximately 90 percent of the material discharged in drilling a well (cuttings and drilling fluid) settles rapidly to the seafloor, while 10 percent forms a plume of fine mud that drifts in the water column (Neff, 2005). Shunting of drill muds and cutting is required for wells drilled in the vicinity of topographic features. Shunting restricts the cuttings to a smaller area and places the turbidity plume near the seafloor where the environment is frequently turbid and benthic communities are adapted to high levels of turbidity. Water currents moving turbidity plumes across the seafloor would sweep around topographic features rather than carrying the turbidity over the banks (Bright and Rezak, 1978). Any sediment that may reach coral can be removed by the coral using tentacles and mucus secretion, and physically removed by currents that can shed the mucus-trapped particles from the coral (Shinn et al., 1980; Hudson and Robin, 1980).

With the inclusion of the proposed Topographic Features Stipulation, no discharges of effluents, including produced water would take place within the No Activity Zone. Drill cuttings in areas around the No Activity Zone would be shunted to within 10 m (33 ft) of the seabed. This procedure, combined with USEPA's discharge regulations and permits, should eliminate the threat of discharges reaching and affecting the biota of a topographic high. The impacts that these discharges could cause would be primarily sublethal damages that could lead to a possible disruption or impairment of a few elements at a local scale, but no interference to the general ecosystem performance should occur.

Impacts on the topographic features could occur as a result of oil- and gas-related spills or spills from import tankering. Due to dilution and the depths of the crests of the topographic features, discharges should not reach topographic features in sufficient concentrations to cause impacts. Tanker accidents would result in surface oil spills, which generally do not mix below a depth of 10-20 m (33-66 ft) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002), which should protect most topographic features, very few of which rise to within 15 m (50 ft) of the sea surface. Any dispersed surface oil from a tanker spill that may reach the benthic communities of topographic features in the Gulf of Mexico would be expected to be at very low concentrations (less than 1 ppm) (McAuliffe et al., 1981a and 1981b;

Lewis and Aurand, 1997). Such concentrations would not be life threatening to larval or adult stages based on experiments conducted with coral (Lewis, 1971; Elgershuizen and De Kruijf, 1976; Knap, 1987; Wyers et al., 1986; Cohen et al., 1977) and observations after oil spills (Jackson et al., 1989; Guzmán et al., 1991). Any dispersed or physically mixed oil in the water column that comes in contact with corals, however, may evoke short-term negative responses by the organisms, such as reduced feeding and photosynthesis or altered behavior (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Potential blowouts could impact the biota of the topographic features. Based on the proposed Topographic Features Stipulation, few blowouts, if any, would reach the No Activity zone around the topographic features. The proposed stipulation creates a buffer zone around the banks that would protect them from direct impacts by damaging amounts of suspended sediment from a seafloor blowout. Most of the oil from a seafloor blowout would rise to the surface, but some of it may be entrained in the water column as a subsea plume. Oil in a subsea plume could be carried to a topographic feature. The resulting level of impacts depends on the concentration of the oil when it contacts the habitat. The farther the blowout is from the topographic feature, the more dispersed the oil and sediment would become, reducing the possible impacts. Also, because currents sweep around topographic features instead of over them, subsea oil should be directed away from the more sensitive communities on the upper levels of topographic features (Rezak et al., 1983; McGrail, 1982). If oil were to contact the topographic features, the impacts may include loss of habitat, biodiversity, and live coverage; change in community structure; and failed reproductive success. In the highly unlikely event that oil from a subsurface spill could reach a coral-covered area in lethal concentrations, the recovery of this area could take in excess of 10 years (Fucik et al., 1984).

The cumulative impact of the possibility of a future oil spill along with the DWH event is anticipated to be extremely small. It is highly unlikely that the topographic features of the CPA were or will be impacted by the DWH event because of their distance from the blowout. Impacts may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. These impacts, if they occur, may be difficult to measure.

Platforms will be removed from the OCS Program each year; some may be in the vicinity of topographic features (**Table 3-2**). However, the proposed Topographic Features Stipulation prevents the installation of platforms near the No Activity Zone, thus reducing the potential for impact from platform removal. The explosive removals of platforms are far enough away to prevent impacts to the biota of the topographic features.

Summary and Conclusion

Activities causing mechanical disturbance represent the greatest threat to the topographic features. This would, however, be prevented by the continued application of the proposed Topographic Features Stipulation. Potential OCS-related impacts include anchoring of vessels and structure emplacement, operational discharges (drilling muds and cuttings, and produced waters), blowouts, oil spills, and structure removal.

The proposed Topographic Features Stipulation would preclude mechanical damage caused by oil and gas leaseholders from impacting the benthic communities of the topographic features and would protect them from operational discharges by establishing a buffer around the feature. As such, little impact would be incurred by the biota of the topographic features. The USEPA discharge regulations and permits would further reduce discharge-related impacts.

Blowouts could potentially cause damage to benthic biota; however, due to the application of the proposed Topographic Features Stipulation, blowouts would not reach the No Activity zone surrounding the topographic features and associated biota, resulting in little impact on the features. If a subsea oil plume is formed, it could contact the habitats of a topographic feature; this contact may be restricted to the lower, less sensitive levels of the banks and/or may be swept around the banks with the prevailing water currents. The farther the oil source is from the bank, the more dilute and degraded the oil would be when it reaches the vicinity of the topographic features.

Oil spills can cause damage to benthic organisms when the oil contacts the organisms. The proposed Topographic Features Stipulation would keep sources of OCS spills at least 152 m (500 ft) away from the immediate biota of the topographic features. In the unlikely event that oil from a subsurface spill would reach the biota of a topographic feature, the effects would be primarily sublethal for corals and much of

the other fully developed biota. In the event that oil from a subsurface spill reached an area containing hermatypic coral cover in lethal concentrations, the recovery could take in excess of 10 years (Fucik et al., 1984). Finally, in the unlikely event a freighter, tanker, or other oceangoing vessel related to OCS Program activities or non-OCS-related activities sank and proceeded to collide with the topographic features or associated habitat releasing its cargo, recovery could take years to decades, depending on the extent of the damage. Because these events are rare in occurrence, the potential of impacts from these events is considered low.

Non-OCS activities could mechanically disrupt the bottom (such as anchoring and treasure-hunting activities, as previously described). Natural events such as hurricanes or the collapse of the tops of the topographic features (through dissolution of the underlying salt structure) could cause severe impacts. The collapsing of topographic features is unlikely and would impact a single feature. Impacts from scuba diving, fishing, ocean dumping, and discharges or spills from tankering of imported oil could have detrimental effects on topographic features.

Overall, the incremental contribution of the CPA proposed action to the cumulative impact is negligible because of the implementation of the proposed Topographic Features Stipulation, which would limit mechanical impacts and operational discharges.

4.1.1.8. Sargassum

A description of *Sargassum* as a resource has not been included in previous NEPA evaluations conducted in the Gulf of Mexico by BOEMRE. Therefore, there is no prior discussion in the Multisale EIS or the 2009-2012 Supplemental EIS upon which to tier or information from these documents that could be incorporated by reference.

4.1.1.8.1. Description of the Affected Environment

Sargassum is one of the most ecologically important brown algal genera found in the pelagic environment of tropical and subtropical regions of the world. The pelagic complex in the GOM is mainly comprised of *S. natans* and *S. fluitans* (Lee and Moser, 1998; Stoner, 1983; Littler and Littler, 2000). Both species of macrophytes (aquatic plants) are hyponeustonic (living immediately below the surface) and fully adapted to a pelagic existence (Lee and Moser, 1998). Also known as gulf-weed or sea holly (Coston-Clements et al., 1991; Lee and Moser, 1998), *Sargassum* is characterized by a brushy, highly branched thallus (stem) with numerous leaf-like blades and berrylike pneumatocysts (air bladders or floats) (Coston-Clements et al., 1991; Lee and Moser, 1998; Littler and Littler, 2000). The air bladders contain mostly oxygen with some nitrogen and carbon dioxide, allowing for buoyancy. These floating plants may be up to a few meters in length and may be found floating alone or in larger rafts or mats that support communities of fish and a variety of other marine organisms. The distribution, size, and abundance of *Sargassum* mats varies depending on environmental and physiochemical factors such as temperature, salinity, and dissolved oxygen.

Habitat

Sargassum provides islands of high energy and carbon content in an otherwise nutrient- and carbon-poor environment (Stoner, 1983). Sargassum mats support a diverse assemblage of marine organisms including micro- and macro-epiphytes (plants that grow on plants) (Carpenter and Cox, 1974; Coston-Clements et al., 1991), fungi (Winge, 1923), more than 100 species of invertebrates (Coston-Clements et al., 1991), over 100 species of fish (Dooley, 1972; Stoner, 1983), four species of sea turtles (Carr, 1987; Manzella et al., 2001), and various marine birds (Lee and Moser, 1998). *Sargassum* serves as nurseries, sanctuaries, and forage grounds for both commercially and recreationally exploited species. Numerous epipelagic fish (fish in upper ocean waters, where light penetrates) use the *Sargassum* as a source of food, certain flying fish lay eggs in the floating mats, and other fish use it as nursery grounds (Adams, 1960; Bortone et al., 1977; Dooley, 1972). Sea turtles have been seen using the protective mats for passive migration as hatchlings (Carr and Meylan, 1980). These communities may also vary depending on the environmental and physiochemical factors known to affect *Sargassum*, resulting in variable species composition, life histories, and diversity. It has been noted that inshore *Sargassum* communities differ in species composition than offshore communities, due to the varied effects of salinity and dissolved

oxygen. Recent findings suggest that *Sargassum* provides critical habitat that may have an influence on the recruitment success of several species (South Atlantic Fishery Management Council, 2002; Wells and Rooker, 2004).

Invertebrates

Epiphytic cyanobacteria contribute to overall production and nutrient recycling within the *Sargassum* complex (Wells and Rooker, 2004). The algae is colonized first by bacteria, followed by hydroids and bryozoans, which provide the base of a food web containing a variety of invertebrates, fishes, and sea turtles (Bortone et al., 1977; Dooley, 1972).

Both sessile and motile invertebrates are found within the *Sargassum* community. Epifauna (animals living on the substrate) include colonial hydroids, encrusting bryozoans, the polychaete *Spirorbis*, barnacles, sea spiders, and the tunicate *Diplosoma*. Older plants can become heavily encrusted with these organisms, causing them to sink to the seafloor. A sunken mat will eventually disintegrate, providing further nourishment for animals in deeper water (Coston-Clements et al., 1991; Parr, 1939). Some of the motile fauna found within the floating communities include polychaetes, flatworms, nudibranchs, decapod crustaceans (such as *Latreutes* and *Leander* shrimps and *Portunus* crabs), and various molluscs (including the *Sargassum* snail *Litiopa melanostoma*) (Parr, 1939).

Fish

Fish assemblages in *Sargassum* mats located in the GOM and the Atlantic have shown similarities in species composition. In studies by Dooley (1972) and Bortone et al. (1977), 90-97 percent of the total catch was represented by jacks, pompanos, jack mackerels, scads, triggerfish, filefish, seahorse, pipefish, and frogfish in both regions. The abundance of juvenile fish associated with these mats suggests that they serve as an important nursery habitat for numerous species, including filefish, sergeant majors, tripletail, silver mullet, flying fish, and various jacks (Dooley, 1972). Some species that are endemic to *Sargassum* utilize the habitat for early life stages as well as adult stages, while other species may rely on the habitat only as a source of food and protection during early life stages (Wells and Rooker, 2004). The patterns of habitat use by many of the juvenile fish associated with *Sargassum* have exhibited spatial and temporal variability. Monthly influences such as environmental conditions appear to have an important role in the *Sargassum* fish assemblages within the northwestern GOM. By serving as an important nursery habitat for pelagic, benthic, and even estuarine species, *Sargassum* may have influence on the recruitment success of the fishes using it as habitat.

The importance of *Sargassum* differs among species depending on its role as essential fish habitat. The NMFS has designated *Sargassum* as essential fish habitat in the south Atlantic (Coston-Clements, 1991; USDOC, NMFS, 2010a). However, more studies are needed in order to evaluate the importance of *Sargassum* as habitat in the northwestern GOM, where *Sargassum* is the predominant cover and structure offering habitat for pelagic species at the sea surface.

Turtles

Four of the five species of sea turtles found in the GOM are associated with floating *Sargassum* (Carr and Meylan, 1980; Carr, 1987; Coston-Clements et al., 1991; Schwartz, 1988). The hatchlings of loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and hawksbill (*Eretmochelys imbricata*) sea turtles are thought to find the *Sargassum* rafts when actively seeking frontal zones, then utilizing the habitat as foraging grounds and protection during their pelagic "lost years" (juvenile years in which turtle sightings are scarce) (Carr, 1987; Coston-Clements et al., 1991). Schwartz (1988) reported numerous loggerhead hatchlings during commercial trawling for *Sargassum* in the Atlantic. This provided the largest count of hatchlings on record to date. After Hurricane David hit the Gulf in September 1979, Carr and Meylan (1980) collected dead and live turtles that were found in the *Sargassum* mats that had washed up on Cocoa Beach. The stomach content of the turtles was solely *Sargassum* floats and leafy parts, further emphasizing the importance of the habitat for pelagic growth stages of sea turtles.

Birds

A study by Lee and Moser (1998) found that the presence or absence of *Sargassum* drives local abundance and occurrence of certain species of marine birds. Various avian species utilize the resource in specific ways, by feeding on small fishes and other organisms in the *Sargassum* communities. In Lee and Moser's study, birds with over 25 percent of their prey living in *Sargassum* are classified as *Sargassum* specialists. Specialist species included shearwaters (59%), masked boobies (100%), phalaropes (62%), and various species of terns (40-60%). Both the GOM and Atlantic pelagic environment provide nutrient poor surface waters with low productivity. Therefore, the importance of this highly productive *Sargassum* community to seabird abundance and seasonal distribution is assumed to be high.

Distribution

Approximately 1 million wet cubic tons of *Sargassum* (*natans* and *fluitans*) is estimated to grow and circulate in the GOM annually. Over 80 percent of this is the dominant species *S. natans* (Parr, 1939). Wells and Rooker (2004) suggest that the abundance and age of *Sargassum* increases when found in slow-moving gyres, such as found in the western GOM and the Sargasso Sea (middle of the North Atlantic). These waters provide the ideal environment for *Sargassum* to grow and provide abundant habitat for associated organisms (Dooley, 1972).

Research by Gower and King (2008) suggests that the northwest GOM is the "major nursery area" for *Sargassum* that supplies the Atlantic population. The transportation of these plants is influenced by winds and ocean currents, and the winds over the Gulf blow predominantly from the east to the west and adjacent waters move from the west to the east (Parr, 1939; Rhodes et al., 1989). *Sargassum* originates in the northwestern GOM in March of each year, where it remains for long periods of time in the slowly rotating gyres of western GOM waters (Gower et al., 2006, Gower and King, 2008). In the months of May, June, and July, *Sargassum* is at its most abundant. The *Sargassum* begins to expand and spreads eastward into the central and eastern Gulf waters, taking up to 2 months to move across the Gulf, where it will eventually exit in the Loop Current. The movement of passive drift buoys deployed to track water currents corroborates this pattern of *Sargassum* movement from the Gulf to the Atlantic (Gower et al., 2006). It was previously assumed that *Sargassum* in the Atlantic originated in the Sargasso Sea. However, Gower and King (2008) used satellite imagery to determine that the Loop Current and Gulf Stream are responsible for distributing a large amount of *Sargassum* from the GOM into the Atlantic near Cape Hatteras in July and August. From September through February, the *Sargassum* that was distributed in the Atlantic mixes into the Sargasso Sea, loops around to the south, and dies in the waters north of the Bahamas, about a year after it originated in the GOM.

Historic Impacts on *Sargassum*

Studies by Parr (1939) and Stoner (1983) suggest that a significant decrease in *Sargassum* biomass has occurred from the 1930's through the 1980's, presumably because of increased pollutants and toxins in the pelagic environment. Burns and Teal (1973) found that *Sargassum* and its associates accumulate and concentrate petroleum hydrocarbons. An increase in petroleum pollution and associated toxic effects in the GOM may have attributed to the declining macrophyte populations. *Sargassum* has been noted to have higher levels of toxins than in surrounding water samples in polluted areas. Oceanographic processes that concentrate *Sargassum* into mats and rafts may also concentrate toxic substances. Therefore, it may be assumed that *Sargassum* can be found in areas where oil, dispersants, and other pollutants have accumulated since the DWH event.

The highest concentration of *Sargassum* in the GOM during the months of June and July was in the vicinity of the DWH event. Since *Sargassum* would occupy the same portion of water as oil on the sea surface and dispersed oil, it can be presumed that oil has damaged or destroyed some *Sargassum* mats and associated organisms. Dead *Sargassum* would have sunk to the seafloor, possibly affecting localized areas of benthic habitat. A noticeable decline in GOM *Sargassum* biomass as a result of the DWH event may also adversely affect the biomass of *Sargassum* in Atlantic waters because of the annual movement of *Sargassum* from the GOM into the Atlantic (Gower and King, 2008). Once water quality in the GOM returns to pre-DWH event conditions, *Sargassum* and its associated communities may take additional time before displaying pre-DWH event abundance and species composition.

A broad Internet search for relevant new information, as well as a search for scientific journal articles, was conducted using a publicly available search engine. A search for relevant information gathered during the *Ixtoc* spill of 1979 was conducted. In addition, the websites for Federal and State agencies, as well as other organizations, were reviewed for newly released information. Sources investigated include the South Atlantic Fishery Management Council, coordinated communications with the Gulf of Mexico Alliance, USEPA, USGS, and coastal universities. Interviews with personnel from academic institutions and governmental resource agencies were conducted to determine the availability of new information. In addition, there are ongoing NOAA- and National Science Foundation-funded research projects that are investigating the *Sargassum* distribution and impacts from the DWH event.

4.1.1.8.2. Impacts of Routine Events

Impact-producing factors associated with routine events for the CPA proposed action that could affect *Sargassum* may include (1) drilling discharges (muds and cuttings); (2) produced water and well treatment chemicals; (3) operational discharges (deck drainage, sanitary and domestic water, bilge and ballast water); and (4) physical disturbance from vessel traffic and the presence of exploration and production structures (i.e., rigs, platforms, and MODU’s).

Drilling activities differ from other routine activities in the use of drilling muds and the discharge of drill cuttings. Modern drilling muds are typically synthetic-based muds. These muds are more costly than water-based muds and are routinely recycled rather than released. The USEPA regulates the composition of drilling muds to limit toxic components permitted for use. Some muds are released during initial spudding of the well (the first segment of the well, before the outer casing is installed); however, this release of drilling muds is at the seafloor. Since the muds are heavier than seawater, the muds and cuttings from the spudding process generally settle to the seafloor within about 100 m (328 ft) of the well site (CSA, 2006a). Therefore, this release at the seafloor would not affect the pelagic *Sargassum* community, which floats on and near the sea surface.

Drill cuttings are typically discharged from the drill platform (on or near the sea surface) during drilling. Drill cuttings are heavier than seawater and, when released at the sea surface in deep water, generally sink to the seafloor within less than 1,000 m (3,281 ft) of the well site (CSA, 2006a). Cuttings can contain some concentrations of naturally-occurring substances that are toxic, e.g., arsenic, cadmium, mercury, other heavy metals, and hydrocarbons (Neff, 2005). Hydrogen sulfide is also produced from some wells. In addition, some amount of drilling muds is included with the cuttings discharges, as the recycling process is not 100 percent efficient. However, the composition of muds is strictly regulated and discharges of cuttings/muds are tested to ensure that toxicity levels are below the limits allowed by NPDES permits (USEPA, 2004a, 2007d, and 2009a).

The routine discharge of drill cuttings and muds is expected to have little effect on *Sargassum* communities. There are three arguments that support this conclusion. First, as highlighted above, muds and cuttings are heavier than seawater, so they would sink relatively rapidly. This means that the *Sargassum* at or near the sea surface would only be exposed to contact with discharges for a short time. The *Sargassum* would be traveling laterally with the surface water current; at the same time, the muds and cuttings would be rapidly sinking toward the seafloor. Second, the toxicity of muds and cuttings is limited by applicable regulations, so effects can be expected to be low if *Sargassum* is contacted. Third, discharges affect only a localized area of the sea surface. The proposed action is estimated to result in a total of 287 wells in the WPA and 697 wells in the CPA. While this may seem like a large number of wells, they would affect only a very small portion of the 115,645 km^2 (44,651 mi^2) of the WPA and 268,922 km^2 (103,831 mi^2) of the CPA. Although *Sargassum* occurs in most of the northern GOM, it is not abundant, or even present, in all waters at all times. Therefore, only a small portion of pelagic *Sargassum* in the GOM would come in contact with drill cuttings and muds and that contact would be brief.

Produced waters may have an effect on *Sargassum* communities. Water is often a component of the fluid extracted from a well in offshore oil and gas operations. It is more prevalent with oil than with gas extraction. The water is typically separated from the product on a platform and discharged at the sea surface. Produced waters usually have high salinity, high organic carbon, and low dissolved oxygen. They may also contain some added chemicals used in well treatment. These characteristics could make the produced waters toxic to some organisms in the *Sargassum* community, particularly crustaceans and

filter feeders (e.g., bryozoa). However, the produced waters are required to meet toxicity limits defined by NPDES permits and would further diffuse through the water mass, reducing concentrations of any toxic component (USEPA, 2004a, 2007d, and 2009a). The *Sargassum* algae itself has a waxy coating and would be unlikely to be affected by possible short-term exposure.

Platform and service-vessel operational discharges may have an effect on water quality, indirectly affecting *Sargassum* in the immediate area of activity. Since *Sargassum* is ubiquitous in the northern GOM, it will come in contact with operational discharges. However, considering the ratio of the affected area (immediately surrounding the activity) to the entire planning area, and even larger area inhabited by *Sargassum*, it is clear that only a small percent of the total *Sargassum* population would contact operational discharges.

Vessel traffic and the presence of production structures may act as temporary barriers and obstacles for free-floating *Sargassum*. Stationary platforms and their associated fouling communities may snag pelagic *Sargassum* as it passes. In the event that *Sargassum* is caught in the propellers or cooling water intakes of vessels associated with the proposed action, repairable damage may occur to the *Sargassum*.

Further research would enhance our knowledge of the effects, if any, of muds, cuttings, operational discharges, and physical impingement on *Sargassum* and its associated communities. *Sargassum* may have the capacity to absorb chemical substances, which may indirectly affect the health of the *Sargassum* and/or associated organisms. The likelihood that *Sargassum* would contact routine discharges or impinge on ships or stationary platforms is high. However, only a small part of the total population would receive these types of contact, contact would be only for a short time, and concentrations would be low (within permit limits). Given the ratio of *Sargassum* habitat to the surface area of the proposed activities, it may be presumed unlikely that the proposed action would have any lasting effects on *Sargassum* and its associated community.

Summary and Conclusion

Sargassum, as pelagic algae, is a widely distributed resource that is ubiquitous throughout the GOM and northwest Atlantic. Considering its ubiquitous distribution and occurrence in the upper water column near the sea surface, it would contact routine discharges from oil and gas operations. All types of discharges including drill muds and cuttings, produced water, and operational discharges (e.g., deck runoff, bilge water, sanitary effluent, etc.) would contact *Sargassum* algae. However, the quantity and volume of these discharges is relatively small compared with the pelagic waters of the CPA (268,922 km^2 [103,831 mi^2]). Therefore, although discharges would contact *Sargassum*, they would only contact a very small portion of the *Sargassum* population. Because these discharges are highly regulated for toxicity and because they would continue to be diluted in the Gulf water, concentrations of any toxic components would be reduced; therefore, produced-water impacts on *Sargassum* would be minimum. Likewise, impingement effects by service vessels and working platforms and drillships would contact only a very small portion of the *Sargassum* population. The impacts to *Sargassum* that are associated with the proposed action are expected to have only minor effects to a small portion of the *Sargassum* community as a whole. The *Sargassum* community lives in pelagic waters with generally high water quality and would be resilient to the minor effects predicted. It has a yearly cycle that promotes quick recovery from impacts. No measurable impacts are expected to the overall population of the *Sargassum* community.

4.1.1.8.3. Impacts of Accidental Events

Proposed Action Analysis

Impact-producing factors associated with accidental events for the CPA proposed action that could affect *Sargassum* and its associated communities include (1) surface oil and fuel spills and underwater well blowouts, (2) spill-response activities, and (3) chemical spills. These impacting factors would have varied effects depending on the intensity of the spill and the presence of *Sargassum* in the area of the spill.

Oil spills are the major accidental events of concern to the *Sargassum* community. The risk of various sizes of oil spills occurring in the CPA is presented in **Table 3-5**. The possibility of a spill over 10,000 bbl in the OCS of the CPA is estimated to be <1-1 spill, over the 40-year cycle for the proposed

action of the 5-Year Program. Up to two blowouts are estimated to occur in the same period (Table 3-3 of the 2009-2012 Supplemental EIS).

All known reserves in the GOM have specific gravity characteristics that indicate the oil will float to the sea surface. As discussed in Chapter 4.3.1.5.4 of the Multisale EIS, oil discharges that occur at the seafloor from a pipeline or loss of well control would rise in the water column, surfacing almost directly over the source location. Oil on the sea surface has the potential to negatively impact *Sargassum* communities. While components of oil on the sea surface would be removed through evaporation, dissipation, biodegradation and oil-spill cleanup operations, much of it would persist until it contacts a shore. Oil at the sea surface can be mixed into the upper water column by wind and wave action to a depth of 10 m (33 ft) (Lange, 1985; McAuliffe et al., 1975 and 1981a; Knap et al., 1985). With vigorous wave action, the oil can form an emulsion with water that is viscous and persistent.

When dispersants are applied to oil on the sea surface or at depth, its behavior is modified, causing the oil to mix with water. The dispersed oil would be suspended in the water column and would begin to flocculate with particulate matter until it becomes heavy enough to sink to the seafloor. Oil treated with dispersant at depth may form underwater plumes that do not rise to the sea surface. Oil treated with dispersant on the sea surface mixes with the water where its contact with *Sargassum* may be temporarily increased in the upper few meters of the water column. Data from other studies on dispersant usage on surface plumes indicate that a majority of the dispersed oil remained in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). As time passes, the oil begins to adhere to particles in the water column, form clumps, and sink toward the seafloor (ITOPF, 2007; Kingston, 1995).

The effects of oil contact with *Sargassum* communities will vary depending on the severity of exposure. *Sargassum* that contacts concentrated oil that coats the algae would likely succumb to the effects, die, and sink to the seafloor. Any attached organisms would suffer the same fate. Motile organisms that are dependent on the algae for habitat (shrimp, crabs, nudibranchs, snails, sargassum fish, etc.) may also be directly contacted by the oil or may be displaced into open water, resulting in death. *Sargassum* exposed to oil in lower concentrations may suffer sublethal effects. Levels of hydrocarbons, toxins, and chemicals in *Sargassum* from an accidental spill and spill cleanup may be concentrated up to four times that found in the adjacent waters (Burns and Teal, 1973). The effects of concentrated toxins on the macroalgae itself are undefined. It may result in the loss of associated organisms such as attached epifauna that use the algae as a substrate and other organisms that utilize the community as habitat including sea turtles, juvenile fish, and various invertebrates. Pelagic organisms feeding on the community may suffer sublethal effects that could reduce health and reproduction.

A catastrophic spill could affect a sizable portion of the *Sargassum* population. Since *Sargassum* is ubiquitous in the northern GOM, the portion of the population affected would be similar to the portion of the surface waters affected. For example, if 10 percent of the surface waters of the northern GOM are affected by oil, about 10 percent of the *Sargassum* population at that time may come in contact with oil. However, a reliable estimate must also consider the annual cycle of *Sargassum* because density of the algae varies with season and across geographic locations. If the large spill occurs in an area of high or low *Sargassum* density, then a correspondingly higher or lower percent of the *Sargassum* population would be affected. Impacts from a catastrophic spill and cleanup effort could destroy a large enough portion of the population to affect subsequent populations in the Atlantic. The *Sargassum* community lives in pelagic waters with generally high water quality and is expected to show good resilience to the predicted effects of spills. It has a yearly cycle that promotes quick recovery from impacts. No measurable impacts are expected to the overall population of the *Sargassum* community unless a catastrophic spill occurs.

Spill-response activities may contribute to negative impacts on *Sargassum*. The number of vessels working to clean a spill can increase physical damage to the *Sargassum* community, especially in the immediate vicinity of the spill. Vessels damage algae by cutting it with their propellers but impingement in cooling water intake is probably a larger effect. Vessels circulate seawater through shipboard systems as coolant. This can damage *Sargassum* directly; in addition, an antifoulant such as bleach or copper is typically injected to the water to prevent internal growth of organisms inside the systems. Other response activities, such as skimming oil from the sea surface, can also damage and remove *Sargassum*. However, these impacts may be inconsequential, as a large part of the *Sargassum* affected would already be contacted by oil. Another major response activity that may occur is the spraying of dispersant. Direct

effects of dispersant on the *Sargassum* community are unknown but dispersants are known to be toxic to some invertebrates. The use of dispersants is a trade-off to achieve the least overall damage. For example, dispersants may increase short-term contact of oil with *Sargassum* and may have some inherent toxic properties but their use can prevent the formation of persistent emulsions and promote diffusion of oil resulting in biodegradation, clumping, and sinking.

Chemical spills are typically small (a few gallons to a few barrels of product) and are unlikely to produce any measurable impact on *Sargassum* communities. Due to the ubiquitous nature of *Sargassum* over most of the GOM, such spills are negligible to the overall population.

A spill may impact the productivity and longevity of *Sargassum* in an area. A very large spill may produce a measurable effect on the population of *Sargassum* in the Gulf of Mexico, reducing the overall biomass that is flushed into the Atlantic via the Loop Current and Gulf Stream. However, because of the nature of algal growth and the quality of the habitat under normal conditions, a more likely result is that local populations of *Sargassum* are affected that produce short-term measurable effects in the local area with rapid recovery. The *Sargassum* community is widely distributed over a very large area, including two oceans, and appears to have an annual cycle of growth that lends itself to resilient recovery in a short time.

Summary and Conclusion

Sargassum, as pelagic algae, is a widely distributed resource that is ubiquitous throughout the northern GOM and northwest Atlantic. Considering its ubiquitous distribution and occurrence in the upper water column near the sea surface, it would contact potential accidental spills from oil and gas operations. All types of spills including surface oil and fuel spills, underwater well blowouts, and chemical spills would contact *Sargassum* algae. The quantity and volume of most of these spills would be relatively small compared with the pelagic waters of the CPA (268,922 km^2 [103,831 mi^2] of the CPA). Therefore, most spills would only contact a very small portion of the *Sargassum* population. The impacts to *Sargassum* that are associated with the proposed action are expected to have only minor effects to a small portion of the *Sargassum* community as a whole unless a catastrophic spill occurs. In the case of a very large spill, the *Sargassum* algae community could suffer severe impacts to a sizable portion of the population in the northern GOM. The *Sargassum* community lives in pelagic waters with generally high water quality and is expected to show good resilience to the predicted effects of spills. It has a yearly cycle that promotes quick recovery from impacts. No measurable impacts are expected to the overall population of the *Sargassum* community unless a catastrophic spill occurs.

4.1.1.8.4. Cumulative Impacts

Pelagic *Sargassum* algae is an unusual habitat found in the GOM and western Atlantic. It is comprised of floating mats of macroalgae that lives on the surface and upper water column of the sea, along with a varied community of organisms that inhabit it. It also supports a transient community of pelagic fish that take refuge and/or forage in the habitat. See **Chapter 4.1.1.8.1** for a description of *Sargassum* habitat. Several impacting factors can affect *Sargassum*, including impingement by structures and marine vessels, oil and gas drilling discharges, operational discharges, accidental spills, hurricanes, and coastal water quality.

Pelagic *Sargassum* floats at the surface in oceanic waters and is carried by surface currents across the GOM. Vessels transiting the Gulf pass through *Sargassum* mats, producing slight impacts to the *Sargassum* community by their passage, some propeller impacts, and possible impingement on cooling water intakes. None of these would have more than minor localized effects to the mats transited. Oil and gas structures can impede the movement of *Sargassum* mats and may entrap small quantities of the algae. This is expected to be a minor impact with no consequences to the overall *Sargassum* community.

Oil and gas drilling results in discharges of drill cuttings with small quantities of associated drilling muds and well treatment chemicals. Most cuttings from well drilling are discharged from the drill platform at the sea surface. This creates an area of high turbidity in the vicinity of drill operations. Small quantities of drill muds adhere to the cuttings that are discharged. Well treatment chemicals accompany muds into the well and may be discharged in small quantities with the cuttings. The composition of muds is strictly regulated and discharges of cuttings/muds are tested to ensure that toxicity levels are below the limits allowed by NPDES permits (USEPA, 2004a, 2007d, and 2009a). Cuttings discharged at the sea

surface may spread out to 1,000 m (3,280 ft) from the source, depending on currents, with the thickest layers at the well and the majority of the sediment within 250 m (820 ft) (CSA, 2006a; Kennicutt et al., 1996). Fine components of the plume may travel farther but are dispersed in the water column and are distributed widely at low concentrations (CSA, 2004b; NRC, 1983). Contaminants from produced waters are reported in benthic environments up to 1,000 m (3,280 ft) from the source (Peterson et al., 1996; Armstrong et al., 1977; Osenberg et al., 1992). Floating mats of *Sargassum* that pass by a drilling operation would experience short-term exposure to drill cuttings with associated muds and well treatment chemicals. This may cause temporary stress to organisms including changes in respiration rate, abrasion, reduced feeding, reduced water filtration rates, and reduced response to physical stimulus (Anchor Environmental CA, L.P., 2003). These effects would be localized to a small portion of the total *Sargassum* population and represent a negligible amount of the incremental impact to *Sargassum* communities.

Marine vessels of all types produce at least some minor effects to the environment. Oil and gas platforms and drill ships produce similar effects. Runoff water from the decks of ships and platforms may contain small quantities of oil, metals, and other contaminants. Larger vessels and offshore platforms discharge effluents from sanitary facilities (gray water). They also circulate seawater to cool ship's engines, electric generators, and other machines. The cooling water discharge may be up to 11^{o}C (20^{o}F) warmer than the surrounding sea water (USDOT, CG, 2003; Patrick et al., 1993). This temperature difference can accumulate in the vicinity of the discharge. For ships this would only occur when the vessel is stationary, as in port. For oil and gas platforms and drill ships and for offshore Liquid Natural Gas terminals, localized warming of the water could occur (Emery et al., 1997; USDOT, CG, 2003). However, the warm water is rapidly diluted, mixing to background temperature levels within 100 m (328 ft) of the source (USDOT, CG, 2003). Effects from gray water, deck runoff, and cooling water are only notable for stationary locations. Produced waters from stationary locations are rapidly diluted and impacts are only observed within 100 m (328 ft) of the discharge point (Neff and Sauer, 1991; Trefry et al., 1995; Gittings et al., 1992b). Those effects are very localized, with only brief contact to passing *Sargassum* before dilution to background levels. These effects would comprise a negligible portion of the overall cumulative impact to *Sargassum* communities.

Accidental spills of oil and other chemicals could affect *Sargassum* and its community wherever they contact the algae. Small spills would have a limited local effect on a small portion of the *Sargassum* community. Short-term exposure of passing *Sargassum* to high concentrations of oil and chemicals could result in death and sinking of algae and organisms contacted. The size of the overall effect on *Sargassum* would depend on the size of the spill and the success of spill-response efforts. A catastrophic spill such as the DWH event could have noticeable impacts to the overall *Sargassum* community. These impacts could destroy a sizable portion of *Sargassum* habitat wherever the surface slick of oil travels. The effects could reduce the supply of algae transiting from the GOM to the Atlantic. This effect, although large, would contact only a portion of the algae in the region of the spill. *Sargassum* algae is a widespread habitat with patchy distribution across the northern GOM and the western Atlantic. Due to the vegetative production of *Sargassum* algae, the community would likely recover within 1-2 seasons (1-2 years). The probability of occurrence of a catastrophic spill is very low. If such a spill does occur, it would account for a sizable portion of the cumulative impact that affects *Sargassum*, although even such an impact would affect only a portion of the *Sargassum* in one region of its occurrence.

Hurricanes are major natural impacts that affect the *Sargassum* community. The violent surface turbulence of these storms would dislocate many of the organisms living on and in the *Sargassum*. Some of the organisms (those that cannot swim or swim only weakly) such as nudibranchs (sea slugs), shrimp, sargassum fish (*Histrio histrio*), and pipefish (*Syngnathus* spp.) would become separated from the algae. Without cover, many would fall prey to larger fish after the storm; others may sink to the seafloor and die. Some epifauna, such as hydroids, living on the algae may suffer physical damage or be broken off. In addition, hurricanes drive large quantities of *Sargassum* toward shore, into coastal waters having less conducive conditions for *Sargassum* and even stranding large quantities on shore. Although hurricanes offer major physical damage to *Sargassum* communities, these are natural events for which the *Sargassum* is adapted. The general high quality of the pelagic habitat supports a thriving *Sargassum* algae community that can be expected to maintain high resilience, giving it a strong ability to recover from detrimental impacts. Although hurricanes cause widespread physical damage to the *Sargassum* community seasonally, the habitat routinely recovers from these stresses. Hurricane impacts may be a

large part of the cumulative impacts to *Sargassum*, but they are a part of the normal cycle for the community.

Coastal water conditions are normally of lower quality than those found farther offshore in pelagic waters. *Sargassum* mats are often driven toward shore by onshore winds. Some is stranded on coastal barrier islands and beaches. Water quality conditions nearshore are different than the pelagic environment, with much higher turbidity, higher nutrients, and higher levels of contaminants. These conditions can be expected to cause stress to the algae and its inhabitants as they suffer from clogging of gills and filter mechanisms and lower light conditions. Increased coastal urbanization contributes to lower water quality in coastal waters, particularly near the outlets of rivers. This loss of *Sargassum* to shoreward movement is a normal part of community dynamics, although the effects may be exacerbated by increased declines in coastal water quality. As with hurricanes, loss of *Sargassum* to the coastal environment contributes to cumulative impacts for the overall community in the GOM.

Summary and Conclusion

A broad Internet search for relevant new information, as well as a search for scientific journal articles, was conducted using a publicly available search engine. In addition, the websites for Federal and State agencies, as well as other organizations were reviewed for newly released information. Sources investigated include the South Atlantic Fishery Management Council, coordinated communications with the Gulf of Mexico Alliance, USEPA, USGS, and coastal universities. Interviews with personnel from academic institutions and governmental resource agencies were conducted to determine the availability of new information. In addition, there are ongoing NOAA- and National Science Foundation-funded research projects that are investigating the *Sargassum* distribution and impacts from the DWH event. Because of the ephemeral nature of *Sargassum* communities, many activities associated with the proposed action would have a localized and short-term effect. There is also a low probability of a catastrophic spill to occur with the CPA proposed action. The incremental contribution of the proposed action to the overall cumulative impacts on *Sargassum* communities that would result from the OCS Program, environmental factors, and non-OCS related user group activities are expected to be minimal.

4.1.1.9. Chemosynthetic Deepwater Benthic Communities

The BOEMRE has reexamined the analysis for chemosynthetic deepwater benthic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for this resource presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action’s incremental contribution to the cumulative impacts are presented in the Multisale EIS. A brief summary of potential impacts follows. Chemosynthetic communities are susceptible to physical impacts from structure placement, anchoring, and pipeline installation associated with the CPA proposed action; however, the guidance provided in NTL 2009-G40 greatly reduces the risk of these physical impacts by requiring avoidance of potential chemosynthetic communities and by consequence avoidance of other hard-bottom communities. Even in situations where the substantial burial of typical benthic infaunal communities occurred, recolonization from populations from widespread neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms. Potential accidental events associated with the CPA proposed action are expected to cause little damage to the ecological function or biological productivity of the widespread, low-density chemosynthetic communities and the widespread, typical, deep-sea, soft-bottom communities. The most serious, cumulative, impact-producing factor threatening chemosynthetic communities is physical disturbance of the seafloor by OCS activities, which could destroy the organisms of these communities. The incremental contribution of the proposed action to the cumulative impacts is expected to be slight, and adverse impacts would be limited but not completely eliminated by adherence to NTL 2009-G40.

4.1.1.9.1. Description of the Affected Environment

A detailed description of the continental slope and deepwater resources can be found in Chapter 3.2.2.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.5.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the Supplemental EIS, and new information that has become available since both documents were prepared.

Continental Slope and Deepwater Resources

The northern GOM is a geologically complex basin. It has been described as the most complex continental slope region in the world (Carney, 1997 and 1999; Rowe and Kennicutt, 2009). Regional topography of the slope consists of basins, knolls, ridges, and mounds derived from the dynamic adjustments of salt to the introduction of large volumes of sediment over long time scales. This region has become much better known in the last three decades, and the existing information is considerable, both from a geological and biological perspective. The first substantial collections of deep GOM benthos were made during the cruises of the USCG and Geodetic Steamer, *Blake*, between 1877 and 1880. Rowe and Menzel (1971) reported that their deep GOM infauna data were the first quantitative data published for this region. The first major study of the deep northern GOM was performed by a variety of researchers from Texas A&M University between 1964 and 1973 (Pequegnat, 1983). A total of 157 stations were sampled and photographed between depths of 300 and 3,800 m (984 and 12,467 ft) (the deepest part of the GOM). A more recent Agency-funded study was completed by LGL Ecological Research Associates, Inc. and Texas A&M University in 1988, during which a total of 60 slope stations were sampled throughout the northern GOM in water depths between 300 and 3,000 m (9,842 ft) (Gallaway et al., 1988). As part of this multiyear study, along with trawls and quantitative box-core samples, 48,000 photographic images were collected and a large subset was quantitatively analyzed. Another major study, titled *Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study*, was completed in 2009. This 6-year project spanned three field sampling years and included collections of benthos and sediments through trawling, box coring and bottom photography at a total of 51 stations ranging in depth from 213 to 3,732 m (699 to 12,244 ft), including some stations in Mexican waters (Rowe and Kennicutt, 2009).

"Deepwater" is a term of convenience referring (in this use) to vast areas of the Gulf with water depths ≥300 m (984 ft) that are typically covered by pelagic clay and silt. In, on, and directly above these sediments live a wide variety of single-celled organisms, invertebrates, and fish. Their lifestyles are extremely varied and can include absorption of dissolved organic material, symbiosis, collection of food through filtering, mucous webs, seizing, or other mechanisms including chemosynthesis. Chemosynthetic communities are a remarkable assemblage of invertebrates found in association with hydrocarbon seeps. The seeps provide a source of carbon independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth.

The continental slope is a transitional environment influenced by processes of both the shelf (<200 m; 650 ft) and the abyssal GOM (>975 m; 3,199 ft). This transitional character applies to both the pelagic and the benthic realms. The highest values of surface primary production are found in the upwelling areas in the De Soto Canyon region. In general, the eastern GOM is more productive in the oceanic region than is the western GOM. It is generally assumed that all the phytoplankton is consumed by the zooplankton, except for brief periods during major plankton blooms. The zooplankton then egests a high percentage of their food intake as feces that sink toward the bottom.

Deepwater fauna can be grouped into major assemblages defined by depth, including (1) upper slope, (2) mid-slope, (3) lower slope, and (4) abyssal plain (Rowe and Kennicutt, 2009). The 450-m (1,476-ft) isobath defines the truly deep-sea fauna where the aphotic zone begins at and beyond these depths. In these sunlight-deprived waters, photosynthesis cannot occur and processes of food consumption, biological decomposition, and nutrient regeneration occur in cold and dark waters. The lowermost layer containing the last meter of water above the bottom and the bottom itself constitutes the benthic zone. This zone is a repository of sediments where nutrient storage and regeneration take place in association with the solid and semisolid substrate (Pequegnat, 1983). The seven zones previously described by

Pequegnat (1983) and confirmed by LGL Ecological Research Associates, Inc. and Texas A&M University (Gallaway et al., 1988) now appear to be too numerous.

Similar to the continental slope in general, the CPA proposed action area encompasses a vast range of habitats and water depths. The shallowest portions start nearshore at the boundary of State waters and the deepest portions extend nearly into the deepest part of the GOM at approximately 3,500 m (11,483 ft) south of the Sigsbee Escarpment in the Central Gulf. This is not particularly deep for the rest of the world's oceans, but it is within a few hundred meters of the deepest point of the GOM at 3,840 m (12,467 ft) and is only accessible from Mexican waters of the southern Gulf. The proposed lease sale area also includes the lower portions of De Soto Canyon, the most notable sea-bottom feature on the upper slope in this area. Its formation has been attributed to a combination of erosion, deposition, and structural control of salt diapirs clustered in the vicinity (Harbison, 1968). Although the northeastern edge of the canyon has a steep slope, unlike most submarine canyons, De Soto Canyon has a comparatively gentle gradient; however, it does have significant impact on current structure, upwelling features, and resulting increases in biological productivity.

A great number of publications have been derived from the two major Agency-funded deep Gulf studies of Gallaway et al. (1988) and Rowe and Kennicutt (2009). These two studies provide extensive background information on deepwater GOM habitat and biological communities.

The vast majority of the Gulf of Mexico seabed is comprised of soft sediments. Major groups of animals that live in this habitat include the following: (1) bacteria and other microbenthos; (2) meiofauna (0.063-0.3 mm); (3) macrofauna (>0.3 mm); and (4) megafauna (larger organisms such as crabs, sea pens, sea cucumbers, crinoids, and bottom-dwelling [demersal] fish). All of these groups are represented throughout the entire Gulf − from the continental shelf to the deepest abyssal depths.

The continental slope and the abyssal zone (≥1,000 m; 3,281 ft) have the following divisions and characteristic faunal assemblages:

- Shelf-Slope Transition Zone (150-450 m; 492-1,476 ft)—A very productive part of the benthic environment. Demersal fish are dominant, many reaching their maximum populations in this zone. Asteroids, gastropods, and polychaetes are common.
- Archibenthal Zone—Horizon A (475-740 m; 1,558-2,428 ft)—The Horizon A Assemblage is located between 475 and 740 m. Although less abundant, the demersal fish are a major constituent of the fauna, as are gastropods and polychaetes. Sea cucumbers are more numerous.
- Archibenthal Zone—Horizon B (775-950 m; 2,543-3,117 ft)—The Horizon B Assemblage, located at 775-950 m, represents a major change in the number of species of demersal fish, asteroids, and echinoids, which reach maximum populations here. Gastropods and polychaetes are still numerous.
- Upper Abyssal Zone (1,000-2,000 m; 3,281-6,562 ft)—Number of fish species decline while the number of invertebrate species appear to increase; sea cucumbers, *Mesothuria lactea* and *Benthodytes sanguinolenta*, are common; galatheid crabs include 12 species of the deep-sea genera *Munida* and *Munidopsis*, while the shallow brachyuran crabs decline.
- Mesoabyssal Zone (2,300-3,000 m; 7,546-9,843 ft)—Fish species are few, and echinoderms continue to dominate the megafauna.
- Lower Abyssal Zone (3,200-3,800 m; 10,499 to 12,468 ft)—Large asteroid, *Dynaster insignis*, is the most common megafaunal species.

Megafauna: Animals of a size typically caught in trawls and large enough to be easily visible (e.g., crabs, shrimp, benthic fish, etc.) are called megafauna. In the Gulf, most are crustaceans, echinoderms, or benthic fish. Benthic megafaunal communities in the deep Gulf appear to be typical of most temperate continental slope assemblages found at depths from 300 to 3,000 m (984 to 9,843 ft) (USDOI, MMS, 2001a, p. 3-63). Exceptions include the chemosynthetic communities. Although soft-bottom fauna are

expected to predominate, occasional sea pens, sea whips, and sponges are observed during ROV surveys (Geoscience Earth & Marine Services, Inc., 2005).

Megafaunal invertebrate and benthic fish densities appear to decline with depth between the upper slope and the abyssal plain (Pequegnat 1983; Pequegnat et al., 1990). This phenomenon is generally believed to be related to the low productivity in deep, offshore Gulf waters (USDOI, MMS, 2001a, p. 3-60). Megafaunal communities in the offshore Gulf have historically been zoned by depth (see above), which are typified by certain species assemblages (Menzies et al., 1973; Pequegnat, 1983; Gallaway et al., 1988; Gallaway and Kennicutt, 1988; Pequegnat et al., 1990; USDOI, MMS, 2001a, p. 3-64).

Carney et al. (1983) postulated a simpler system of zonation having three zones: (1) a distinct shelf fauna in the upper 1,000 m (3,281 ft); (2) indistinct slope fauna between 1,000 and 2,000 m (3,281 and 6,562 ft); and (3) a distinct abyssal fauna between 2,000 and 3,000 m (6,562 and 9,843 ft).

The baseline Northern Gulf of Mexico Continental Slope (NGMCS) Study conducted in the mid- to late 1980's trawled 5,751 individual fish and 33,695 invertebrates, representing 153 and 538 taxa, respectively. That study also collected 56,052 photographic observations, which included 76 fish taxa and 193 non-fish taxa. The photographic observations were dominated by sea cucumbers, bivalves, and sea pens, groups that were not sampled effectively (if at all) by trawling. Decapod crustaceans dominated the trawls and were fourth in abundance in photos. Decapod density generally decreased with depth but abundance peaks were determined at 500 m (1,640 ft) and between 1,100 and 1,200 m (3,609 and 3,937 ft), beyond which numbers diminished. Fish density, while variable, was generally high at depths between 300 and 1,200 m (984 and 3,937 ft); it then declined substantially.

Gallaway et al. (2003) concluded that megafaunal composition changes continually with depth such that a distinct upper slope fauna penetrates to depths of about 1,200 m (3,937 ft) and a distinct deep-slope fauna is present below 2,500 m (8,202 ft). A broad transition zone characterized by low abundance and diversity occurs between depths of 1,200 and 2,500 m (3,937 and 8,203 ft).

Macrofauna: The benthic macrofaunal component of the NGMCS Study (Gallaway et al., 2003) included sampling in nearby areas at similar depths, both east and west of the proposed action. The study NGMCS examined 69,933 individual macrofauna from over 1,548 taxa; 1,107 species from 46 major groups were identified (Gallaway et al., 2003). Polychaetes (407 species), mostly deposit-feeding forms (196 taxa), dominated in terms of numbers. Carnivorous polychaetes were more diverse, but less numerous than deposit-feeders, omnivores, or scavengers (Pequegnat et al., 1990; Gallaway et al., 2003). Polychaetes were followed in abundance by nematodes, ostracods, harpacticoid copepods, bivalves, tanaidacids, bryozoans, isopods, amphipods, and others. Overall abundance of macrofauna ranged from 518-5,369 individuals/m^2 (Gallaway et al., 1988). The central transect (4,938 individuals/m^2) had higher macrofaunal abundance than either the eastern or western Gulf transects (4,869 and 3,389 individuals/m^2, respectively) (Gallaway et al., 2003).

In the GOM, macrofaunal density and biomass declines with depth from approximately 5,000 individuals/m^2 on the lower shelf-upper slope to several hundred individuals/m^2 on the abyssal plain (USDOI, MMS, 2001a, p. 3-64). This decline in benthos has been attributed to the relatively low productivity of the Gulf offshore open waters (USDOI, MMS, 2001a, p. 3-60). Pequegnat et al. (1990) reported mid-depth maxima of macrofauna in the upper slope at some locations with high organic particulate matter, and Gallaway et al. (2003) noted that the decline with depth is not clear cut and is somewhat obscured by sampling artifacts. There is some suggestion that the size of individuals decrease with depth (Gallaway et al., 2003).

Meiofauna: Meiofauna primarily composed of small nematode worms, as with megafauna and macrofauna, also decline in abundance with depth (Pequegnat et al., 1990; USDOI, MMS, 2001a, p. 3-64; Gallaway et al., 2003). The overall density (mean of 707,000/m^2) of meiofauna is approximately two orders of magnitude greater than the macrofauna throughout the depth range of the slope (Gallaway et al., 1988). These authors reported 43 major groups of meiofauna with nematodes, harpacticoid copepods (adults and larvae), polychaete worms, ostracods, and kinorhynchs accounting for 98 percent of the total numbers. Nematode worms and harpacticoids were dominant in terms of numbers, but polychaetes and ostracods were dominant in terms of biomass, a feature that was remarkably consistent across all stations, regions, seasons, and years (Gallaway et al., 2003). Meiofaunal densities appeared to be somewhat higher in the spring than in the fall. Meiofaunal densities reported in the NGMCS Study are among the highest recorded worldwide (Gallaway et al., 2003). There is also evidence that the presence of chemosynthetic

communities may enrich the density and diversity of meiofauna in the immediate surrounding area (Gallaway et al., 2003).

Microbiota: Less is known about the microbiota in the GOM than the other size groups, especially in deep water (CSA, 2000; USDOI, MMS, 2000, p. IV-15). While direct counts have been coupled with some in situ and repressurized metabolic studies performed in other deep ocean sediments (Deming and Baross, 1993), none have been made in the deep GOM. Cruz-Kaegi (1998) made direct counts using a fluorescing nuclear stain at several depths down the slope, allowing bacterial biomass to be estimated from their densities and sizes. Mean biomass was estimated to be 2.37 g of carbon/m^2 for the shelf and slope combined, and 0.37 g of carbon/m^2 for the abyssal plain. In terms of biomass, data indicate that bacteria are the most important component of the functional infaunal biota. Cruz-Kaegi (1998) developed a carbon cycling budget based on estimates of biomass and metabolic rates in the literature. She discovered that, on the deep slope of the Gulf, the energy from organic carbon in the benthos is cycled through bacteria.

Deepwater Horizon *Event*

The DWH event released an estimated 4.9 million bbl of oil into the water over a period of 87 days. Extensive literature, Internet, and database searches have been conducted for results of scientific data. Although many research cruises have occurred, very few scientific results have been published as of this writing. Descriptions of studies completed or in progress are discussed and available results are included. Although the impacts of the oil spill are not yet known, possible impacts to deepwater benthic communities are discussed.

Several opposing forces dictated the behavior of the oil from the DWH event. The oil was lighter than water and a portion of it was buoyed to the sea surface. However, it was injected into deep water under high pressure, which resulted in vigorous turbulence and the formation of micro-droplets that were not buoyant enough to float rapidly to the surface. The upward movement of the oil was also reduced because methane in the oil was dissolved at high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). The Joint Analysis Group (2010a) reported that oil droplets less than 100 μm in diameter were likely to remain in the water column for several months. Much of the oil was treated with dispersant at the sea surface and at the source in 1,500 m (5,000 ft) of water depth. It is reported that chemically dispersed surface oil from the DWH event remained in the top 6 m (20 ft) of the water column where it mixed with surrounding waters and biodegraded (Lubchenco et al., 2010). Data from other studies on dispersant usage on surface plumes indicate that a majority of the dispersed oil remained in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (7 ft) (McAuliffe et al., 1981a). Any dispersed oil that reached the seafloor from the water's surface during this event would be expected to be at very low concentrations (<1 ppm) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to adhere to particles in the water column, delaying flocculation and sinking to the seafloor (McAuliffe et al., 1981a). Oil exposed to dispersant chemicals became more dispersed and less concentrated the longer it remained floating or suspended in the water column. These oil droplets remained neutrally buoyant in the water column, creating a subsurface plume of oil (Adcroft et al., 2010). Concentrations of dispersed and dissolved oil in the subsea plume were reported to be in the part per million range or less and were generally lower away from the water's surface and away from the wellhead (Adcroft et al., 2010; Haddad and Murawski, 2010; Joint Analysis Group, 2010a; Lubchenco et al., 2010). Depending on how long it remained in the water column, it may have been thoroughly degraded by biological action before contact with the seafloor. Water currents could have carried a plume to contact the seafloor directly but a likely scenario would be for the oil to adhere to other particles and precipitate to the seafloor, much like rainfall (Kingston, 1995; ITOPF, 2007). Oil also would have reached the seafloor through consumption by plankton with excretion distributed over the seafloor (ITOPF, 2007). Distribution of the dispersed oil was dictated by water currents and the physical processes of dispersion and degradation. These mechanisms would result in a wide distribution of small amounts of oil. This oil would be in the process of biodegradation from bacterial action, which would continue on the seafloor, resulting in scattered microhabitats with an enriched carbon environment (Hazen et al., 2010).

Lubchenco et al. (2010) estimated that 26 percent of the total spill volume remained at large in the GOM shortly after the Macondo well was capped on July 16, 2010, and at least some portion of that has probably settled onto the GOM deepwater seafloor. The majority of the seafloor of the Gulf of Mexico is

covered in soft sediments. Oil released from the DWH event may have affected some of the organisms that live on or in these sediments. Direct contact with high concentrations of oil may have resulted in acute toxicity to organisms. Exposures to lower concentrations may have resulted in sublethal impacts such as altered reproduction, growth, respiration, excretion, chemoreception, feeding, movement, stimulus response, and susceptibility to disease (Suchanek, 1993). It is important to note that the effects of oil exposure on soft-bottom benthos are anticipated to have only impacted a relatively small portion of the seafloor of the Gulf of Mexico. The greatest concentrations are expected to be near the wellhead and to decrease with distance from the source. In situations where soft-bottom infaunal communities were negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms, i.e., a matter of days for bacteria and probably less than 1 year for most macrofauna and megafauna species (Lu and Wu, 2006; Netto et al., 2009; Santos et al., 2009). This could take longer for areas affected by direct oil contact in higher concentrations.

A recent report documents damage to a deepwater coral community in an area that oil plume models predict as the direction of travel for subsea oil plumes the from DWH event. Results are still pending but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts (USDOI, BOEMRE, 2010j). A major difference between this occurrence and likely effects on soft bottoms is that the coral community forms structures that protrude up into the water column. These upright corals would be affected by a passing oil plume in a way that a typical smooth soft bottom would not. The oil plume would pass over smooth soft bottom, continuing the process of biodegradation in mid-water and continuing to be dispersed over a wide area.

As of this writing, there are no data on the concentrations of hydrocarbons in sediments or on benthic community structure on the seafloor of the Gulf of Mexico after this event. There are, however, a few data available on hydrocarbons and dissolved oxygen levels in the water column. Water column data may be used to speculate the exposures benthic organisms may have experienced.

The hydrocarbon concentrations in the water column and subsea plume were close to, and below, the values reported by others for dispersed oil in the water column after oil spills. McAuliffe et al. (1981a) reported dispersed oil concentrations between 1 and 3 ppm at 9 m (30 ft) below the sea surface and 1 hour after treatment with dispersant. Lewis and Aurand (1997) reported dispersed oil concentrations <1 ppm at 10 m (33 ft) below the sea surface. Although McAuliffe et al. (1981a) and Lewis and Aurand (1997) did not address subsea plumes, the oil concentrations in the subsea plume appear to be similar to the concentrations reported from surface use of dispersants (Adcroft et al., 2010; Joint Analysis Group, 2010a; Lubchenco et al., 2010).

Water samples collected by the R/V *Weatherbird* on May 23-26, 2010, located 40 nmi (46 mi; 74 km) and 45 nmi (52 mi; 83 km) northeast and 142 nmi (163 mi, 263 km) southeast of the *Deepwater Horizon* rig revealed that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm (Haddad and Murawski, 2010). Concentrations of dispersed and dissolved oil in the subsea plume were reported to be in the part per million range or less and to decrease with distance from the wellhead (Adcroft et al., 2010; Joint Analysis Group, 2010a; Lubchenco et al., 2010). The available data suggest that the concentrations of oil in the water column were low and the oil was dispersed. These data suggest that, if any benthic organisms at the sediment/water interface were exposed to oil as a result of the DWH event, the concentrations were very low (in the part per million range or less).

Surveys performed by Camilli et al. (2010) delineated an underwater oil plume to the west-southwest of the DWH event site, a plume that extended over 35 km (22 mi) and concentrated at a depth of 1,100 m (3,600 ft). The plume was up to 200 m (650 ft) high and over 2 km (1.2 mi) wide in some areas. It was being moved by a water current at a depth of 1,100 m (3,600 ft), with an average speed of 7.8 cm s^{-1} (0.26 ft s^{-1}). Camilli et al. measured monoaromatic petroleum hydrocarbon concentrations in excess of 50 µg L^{-1} (>5 ppm) within the plume.

Joye (2010) reports observation of seafloor conditions that appear to be sedimented oil in the area around the DWH event site (Harris, 2010). The report suggests extensive oil deposition based on the color of the upper sediments in seafloor cores. While this observation may have some merit, lab analyses for verification are pending. The visual appearance and coloration of Joye’s cores are similar to typical cores of the seafloor in this area. Underwater currents are directional, making it unlikely that oil would be distributed in all directions around the well site.

Chemosynthetic Communities

A detailed description of the chemosynthetic communities can be found in Chapter 3.2.2.2.1 of the Multisale EIS. Additional information about chemosynthetic communities for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.5.1.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Chemosynthetic communities are remarkable in that they utilize a carbon source independent of photosynthesis and the sun-dependent photosynthetic food chain that supports all other life on earth. Although the process of chemosynthesis is entirely microbial, chemosynthetic bacteria can support thriving assemblages of higher organisms. This is accomplished through symbiotic relationships in which the chemosynthetic bacteria live within the tissues of tube worms and bivalves and provide a food source for their hosts. The first discovery of deep-sea chemosynthetic communities including higher animals was unexpectedly made at hydrothermal vents in the eastern Pacific Ocean during geological explorations (Corliss et al., 1979). The principal organisms included tube worms, clams, and mussels that derive their entire food supply from symbiotic chemosynthetic bacteria, which obtain their energy needs from chemical compounds in the venting fluids. Similar communities were first discovered in the eastern Gulf of Mexico in 1983 at the bottom of the Florida Escarpment in areas of “cold” brine seepage (Paull et al., 1984). The fauna here was found to be generally similar to vent communities including tube worms, mussels, and rarely, vesicomyid clams.

Two groups fortuitously discovered chemosynthetic communities in the Gulf of Mexico concurrently in November 1984. During investigations by Texas A&M University to determine the effects of oil seepage on benthic ecology (until this investigation, all effects of oil seepage were assumed to be detrimental), bottom trawls unexpectedly recovered extensive collections of chemosynthetic organisms including tube worms and clams (Kennicutt et al., 1985). At the same time, LGL Ecological Research Associates, Inc. was conducting a research cruise as part of the Agency-funded, multiyear Northern Gulf of Mexico Continental Slope Study (LGL Ecological Research Associates, Inc. and Texas A&M University, 1986). Bottom photography resulted in clear images of vesicomyid clam chemosynthetic communities. Photography during the same LGL cruise also documented tube-worm communities in situ in the Gulf of Mexico for the first time (Boland, 1986) prior to the initial submersible investigations and firsthand descriptions of Bush Hill in 1986 (Rosman et al., 1987; MacDonald et al., 1989).

Distribution

There is a clear relationship between known hydrocarbon discoveries at great depth in the Gulf slope and chemosynthetic communities, hydrocarbon seepage, and authigenic minerals, including carbonates at the seafloor (Sassen et al., 1993a and 1993b). Chemosynthetic bacteria form living mats at seep sites and precipitate carbonates. While the hydrocarbon reservoirs are broad areas several kilometers beneath the Gulf, chemosynthetic communities occur in isolated areas with thin veneers of sediment only a few meters thick.

The northern Gulf of Mexico slope includes a stratigraphic section more than 10 km (6 mi) thick that has been profoundly influenced by salt movement. Mesozoic source rocks from Upper Jurassic to Upper Cretaceous generate oil in most of the Gulf slope fields (Sassen et al., 1993a and 1993b). Migration conduits supply fresh hydrocarbon materials through a vertical scale of 6-8 km (4-5 mi) toward the surface. The surface expressions of hydrocarbon migration are referred to as seeps. Geological evidence demonstrates that hydrocarbon and brine seepage persists in spatially discrete areas for thousands of years. The time scale for oil and gas migration (combination of buoyancy and pressure) from source systems is on the scale of millions of years (Sassen, 1998). Seepage from hydrocarbon sources through faults towards the surface tends to be diffused through the overlying sediment, carbonate outcroppings, and hydrate deposits so the corresponding hydrocarbon seep communities tend to be larger (a few hundred meters wide) than chemosynthetic communities found around the hydrothermal vents of the Eastern Pacific (MacDonald, 1992). There are large differences in the concentrations of hydrocarbons at seep sites.

The widespread nature of Gulf of Mexico chemosynthetic communities was first documented during contracted investigations by the Geological and Environmental Research Group (GERG) of Texas A&M

University for the Offshore Operators Committee (Brooks et al., 1986). The occurrence of chemosynthetic organisms dependent on hydrocarbon seepage has been documented in water depths as shallow as 290 m (951 ft) (Roberts et al., 1990) and as deep as 2,200 m (7,218 ft) (MacDonald, 1992). This depth range specifically places chemosynthetic communities in the deepwater region of the Gulf of Mexico, which is defined as water depths greater than 300 m (984 ft). Chemosynthetic communities are not found on the continental shelf. At least 69 communities are now known to exist in the Gulf (**Figure 4-12**). Although a systematic survey has not been done to identify all chemosynthetic communities in the Gulf, there is evidence indicating that many more such communities may exist. The depth limits of discoveries probably reflect the limits of exploration (lack of submersibles capable of depths over 1,000 m [3,281 ft]). MacDonald et al. (1993 and 1996) have analyzed remote-sensing images from space that reveal the presence of oil slicks across the north-central Gulf of Mexico. Results confirmed extensive natural oil seepage in the Gulf, especially in water depths greater than 1,000 m (3,281 ft). A total of 58 additional potential locations were documented where seafloor sources were capable of producing perennial oil slicks (MacDonald et al., 1996). Estimated seepage rates ranged from 4 to 70 bbl/day compared with less than 0.1 bbl/day for ship discharges (both normalized for 1,000 mi^2 [3,430 km^2]). This evidence considerably increases the area where chemosynthetic communities dependent on hydrocarbon seepage may be expected.

The densest aggregations of chemosynthetic organisms have been found at water depths of around 500 m (1,640 ft) and deeper. The best known of these communities was named Bush Hill by the investigators who first described it (MacDonald et al., 1989). It is a surprisingly large and dense community of chemosynthetic tube worms and mussels at a site of natural petroleum and gas seepage over a salt diapir in Green Canyon Block 185. The seep site is a small knoll that rises about 40 m (131 ft) above the surrounding seafloor in water about 580 m (1,903 ft) deep.

Stability

According to Sassen (1998), the role of naturally occurring methane hydrates at chemosynthetic communities has been greatly underestimated. Gas hydrates are a unique and poorly understood class of chemical substances in which molecules of one material (in this case water in solid state—ice) form an open lattice that physically encloses molecules of a certain size (in this case – methane) in a cage-like structure without chemical bonding. The biological alteration of frozen gas hydrates was first discovered during the recent Agency-funded study *Stability and Change in Gulf of Mexico Chemosynthetic Communities* (Sager, 1997). It is hypothesized that the dynamics of hydrate alteration could play a major role as a mechanism for the regulation of the release of hydrocarbon gases to fuel biogeochemical processes and could also play a substantial role in community stability (MacDonald, 1998). Recorded bottom-water temperature excursions of several degrees in some areas such as the Bush Hill site (4-5 °C; [39-41 °F] at 500-m [1,640-ft] depth) are believed to result in dissociation of hydrates, resulting in an increase in gas fluxes (MacDonald et al., 1994). Although not as destructive as the volcanism at vent sites of the mid-ocean ridges, the dynamics of shallow hydrate formation and movement clearly affects sessile animals that form part of the seepage barrier. There is the potential for an entire layer of shallow hydrate to break free of the bottom and result in considerable impact to local communities of chemosynthetic fauna. At deeper depths (>1,000 m; >3,281 ft), the bottom-water temperature is colder (by approximately 3 °C [37 °F]) and undergoes less fluctuation. The formation of more stable and probably deeper hydrates influences the flux of light hydrocarbon gases to the surface, thus influencing the surface morphology and characteristics of chemosynthetic communities.

Powell (1995) reported on the notable uniqueness of each chemosynthetic community site. Through taphonomic studies (death assemblages of shells) and interpretation of seep assemblage composition from cores, Powell (1995) reported that, overall, seep communities were persistent over periods of 500-1,000 years. Some sites retained optimal habitat over geological time scales. Powell reported evidence of mussel and clam communities persisting in the same sites for 500-4,000 years. Powell also found that both the composition of species and trophic tiering of hydrocarbon seep communities tend to be fairly constant across time, with temporal variations only in numerical abundance. He found few cases in which the community type changed (from mussel to clam communities, for example) or had disappeared completely. Faunal succession was not observed. Surprisingly, when recovery occurred after a past destructive event, the same chemosynthetic species reoccupied a site. There was little evidence of

catastrophic burial events, but two such instances were found in mussel communities in Green Canyon Block 234.

Precipitation of authigenic carbonates and other geologic events will undoubtedly alter surface seepage patterns over periods of 1-2 years; although through direct observation, no changes in chemosynthetic fauna distribution or composition were observed at seven separate study sites (MacDonald et al., 1995). A slightly longer period (12 years) can be referenced in the case of Bush Hill, the first community described in situ in 1986. No mass die-offs or large-scale shifts in faunal composition have been observed over the 12-year history of research at this site.

Biology

MacDonald et al. (1990) has described four general community types. These are communities dominated by Vestimentiferan tube worms (*Lamellibrachia c.f. barhami* and *Escarpia*.sp.), mytilid mussels (Seep Mytilid Ia, Ib, and III, and others), vesicomyid clams (*Vesicomya cordata* and *Calyptogena ponderosa*), and infaunal lucinid or thyasirid clams (*Lucinoma* sp. or *Thyasira* sp.). These faunal groups tend to display distinctive characteristics in terms of how they aggregate, the size of aggregations, the geological and chemical properties of the habitats in which they occur and, to some degree, the heterotrophic fauna that occur with them. Many of the species found at these cold seep communities in the Gulf are new to science and remain undescribed. As an example, at least six different species of seep mussels have been collected, but none is yet described.

Individual lamellibrachid tube worms, the longer of two taxa found at seeps (the other is an *Escarpia*-like species but probably a new genus), can reach lengths of 3 m (10 ft) and live hundreds of years (Fisher et al., 1997). Growth rates determined from recovered marked tube worms have been variable, ranging from no growth of 13 individuals measured one year to a maximum growth of 20 mm/yr (0.8 in/yr) in a *Lamellibrachia* individual. Average growth rate was 2.5 mm/yr (0.1 in/yr) for the *Escarpia*-like species and 7.1 mm/yr (0.28 in/yr) for lamellibrachids. These are slower growth rates than those of their hydrothermal vent relatives, but *Lamellibrachia* individuals can reach lengths 2-3 times that of the largest known hydrothermal vent species. Lamellibrachid tube worms over 3 m (10 ft) long have been collected on several occasions. Tube worms of this length are probably over 400 years old (Fisher, 1995). Vestimentiferan tube worm spawning is not seasonal and recruitment is episodic.

Growth rates for methanotrophic mussels at cold seep sites have been reported (Fisher, 1995). General growth rates were found to be relatively high. Adult mussel growth rates were similar to mussels from a littoral environment at similar temperatures. Fisher also found that juvenile mussels at hydrocarbon seeps initially grow rapidly, but the growth rate drops markedly in adults; they grow to reproductive size very quickly. Both individuals and communities appear to be very long lived. These methane-dependent mussels have strict chemical requirements that tie them to areas of the most active seepage in the Gulf of Mexico. As a result of their rapid growth rates, mussel recolonization of a disturbed seep site could occur relatively rapidly. There is some early evidence that mussels also have some requirement of a hard substrate and could increase in numbers if suitable substrate is increased on the seafloor (Fisher, 1995).

Unlike mussel beds, chemosynthetic clam beds may persist as a visual surface phenomenon for an extended period without input of new living individuals because of low dissolution rates and low sedimentation rates. Most clam beds investigated by Powell (1995) were inactive, with little sign of growth. Living individuals were rarely encountered. Powell reported that, over a 50-year time span, local extinctions and recolonization should be gradual and exceedingly rare.

Extensive mats of free-living bacteria are also evident at hydrocarbon seep sites. These bacteria may compete with the major fauna for sulfide and methane energy sources and may also contribute substantially to overall production (MacDonald, 1998). The white, nonpigmented mats were found to be an autotrophic sulfur bacteria *Beggiatoa* species, and the orange mats possessed an unidentified nonchemosynthetic metabolism (MacDonald, 1998).

Preliminary information has been presented by Carney (1993) concerning the nonchemosynthetic animals (heterotrophs) found in the vicinity of hydrocarbon seeps. Heterotrophic species at seep sites are a mixture of species unique to seeps (particularly molluscs and crustacean invertebrates) and those that are a normal component from the surrounding environment. Carney reports a potential imbalance that

could occur as a result of chronic disruption. Because of sporadic recruitment patterns, predators could gain an advantage, resulting in exterminations in local populations of mussel beds.

Detection

Chemosynthetic communities cannot be reliably detected directly using geophysical techniques; however, hydrocarbon seeps and chemosynthetic communities living on them modify the near-surface geological characteristics in ways that can be remotely detected. These known sediment modifications include the following: (1) precipitation of authigenic carbonate in the form of micronodules, nodules, or rock masses; (2) formation of gas hydrates; (3) modification of sediment composition through concentration of hard chemosynthetic organism remains (such as shell fragments and layers); (4) formation of interstitial gas bubbles or hydrocarbons; and (5) formation of depressions or pockmarks by gas expulsion. These features give rise to acoustic effects such as wipeout zones (no echoes), hard bottoms (strongly reflective echoes), bright spots (reflection enhanced layers), or reverberant layers (Behrens, 1988; Roberts and Neurauter, 1990). Potential locations for most types of communities can be determined by careful interpretation of these various geophysical modifications, but to date, the process remains imperfect and confirmation of living communities requires direct visual techniques.

As part of the Agency-funded study, *Stability and Change in Gulf of Mexico Chemosynthetic Communities*, Sager (1997) characterized the geophysical responses of seep areas that support chemosynthetic communities so that a protocol has been refined to use geophysical remote-sensing techniques to locate chemosynthetic communities reliably. One objective is to use geophysical mapping techniques to reduce the seafloor area that may require searching by much slower and expensive near-bottom techniques.

Effects of the *Deepwater Horizon* Event on the Baseline of Chemosynthetic Communities

The DWH event released an estimated 4.9 million bbl of oil into the water over a period of 87 days. Extensive literature, Internet, and database searches have been conducted for results of scientific data. Although many research cruises have occurred, very few scientific results have been published as of this writing. Descriptions of studies completed or in progress are discussed previously in this section on deepwater environments. Possible impacts to chemosynthetic communities are discussed below.

A recent report documents damage to a deepwater coral community in an area that oil plume models predict as the direction of travel for subsea oil plumes from the DWH event. Results are still pending, but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts (USDOI, BOEMRE, 2010j). Coral and chemosynthetic communities form structures that protrude up into the water column above the seafloor, making them more susceptible to impacts from a passing oil plume. It is possible that chemosynthetic communities could have been affected by a passing oil plume. Research projects are continuing to investigate these areas to assess the impacts. Chemosynthetic communities that received low quantities of well-dispersed oil undergoing biodegradation likely experienced little negative effect. Exposure may have been similar to normal conditions for these communities or may have caused some fluctuation in health, resulting in slower growth or delayed spawning. Exposures to low concentrations may have resulted in sublethal impacts such as altered reproduction, growth, respiration, excretion, chemoreception, feeding, movement, stimulus response, and susceptibility to disease (Suchanek, 1993). Communities exposed to more concentrated oil may have experienced detrimental effects including death of affected organisms, tissue damage, lack of growth, interruption of reproductive cycles, and loss of gametes. Other invertebrates associated with chemosynthetic communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure.

4.1.1.9.2. Impacts of Routine Events

Background/Introduction

A detailed description of the possible impacts from routine activities associated with the CPA proposed action on chemosynthetic communities is presented in Chapter 4.2.2.1.4.2.1 of the Multisale EIS and in Chapter 4.1.5.2.1 of the 2009-2012 Supplemental EIS.

Chemosynthetic communities are susceptible to physical impacts from drilling discharges, structure placement (including templates or subsea completions), anchoring, and pipeline installation. In deep water as opposed to shallower areas on the continental shelf, discharges of drilling fluids and cuttings at the sea surface are spread across broad areas of the seafloor and are generally distributed in thinner accumulations. The physical disturbances by structures themselves are typically limited to anchors for holding floating drilling or production facilities over the well sites. Anchors from support boats and ships (or any buoys set out to moor vessels), floating drilling units, barges used for construction of platform structures, pipelaying vessels, and pipeline repair vessels also cause disturbances to small areas of the seafloor. Normal pipelaying activities in deep water could impact areas of chemosynthetic organisms if the pipeline crossed the organisms (pipeline burial is not required at depths where chemosynthetic communities are found).

The policies described in NTL 2009-G40 greatly reduce the risk of these physical impacts by requiring avoidance of potential chemosynthetic communities identified on required geophysical survey records or by requiring photodocumentation to establish the absence of chemosynthetic communities prior to approval of the structure or pipeline emplacement.

Proposed Action Analysis

Chemosynthetic communities could be found in the deeper water areas of the CPA (i.e., Subareas C200-400, C400-800, C800-1600, C1600-2400, and C>2400 m). The levels of projected activity in deep water as a result of the CPA proposed action are shown in **Table 3-2**. There would be an estimated 10-16 production structures ranging from small subsea developments to large developments involving floating, fixed, or subsea structures installed during the 40-year analysis period in the deepwater (>200 m; 656 ft) portions of the CPA as a result of the proposed action.

The NTL 2009-G40 describes BOEMRE's policy to search for and avoid dense chemosynthetic communities or areas that have a high potential for supporting these community types, as interpreted from geophysical records. The policies in the NTL are exercised on all applicable leases and are not optional protective measures. The requirements and discussion of the effectiveness of the NTL are presented in Chapter 4.2.2.1.4.2.1 of the Multisale EIS and in Chapter 4.1.5.2.1 in the 2009-2012 Supplemental EIS. Previous NTL 2000-G20 is superseded by NTL 2009-G40; the major difference in policy with the newer NTL is that it applies to waters as shallow as 300 m (984 ft), and the avoidance distance for muds and cuttings discharge is now 2,000 ft (610 m) from a potential high-density community.

With the CPA proposed action, when geophysical survey information indicates the potential presence of chemosynthetic communities, the biological review process and use of NTL 2009-G40 would apply. This would result in a greatly reduced probability of any impacts occurring.

Summary and Conclusion

Chemosynthetic communities are susceptible to physical impacts from structure placement (including templates or subsea completions), anchoring, and pipeline installation. Because of the avoidance policies described in NTL 2009-G40, the risk of these physical impacts are greatly reduced by requiring the avoidance of potential chemosynthetic communities.

The BOEMRE has reexamined the analysis for impacts to chemosynthetic communities presented in the Multisale EIS and in the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found that would alter the overall conclusion that impacts on chemosynthetic communities from routine activities associated with the CPA proposed action would be minimal to none.

4.1.1.9.3. Impacts of Accidental Events

Background/Introduction

A detailed description of accidental impacts upon chemosynthetic benthic communities can be found in Chapter 4.4.4.2.1 of the Multisale EIS and in Chapter 4.1.5.3.1 of the 2009-2012 Supplemental EIS. The following is a summary of that information with consideration of new information found since publication of the Multisale EIS and the 2009-2012 Supplemental EIS.

Accidental events that could impact chemosynthetic communities are primarily limited to seafloor blowouts. Surface oil and chemical spills are not considered to be a potential source of measurable impacts on chemosynthetic communities because of the water depths at which these communities are located. A blowout at the seafloor could create a crater and could resuspend and disperse large quantities of bottom sediments within a 300-m (984-ft) radius from the blowout site. This buries organisms located within that distance to some degree. The application of avoidance criteria for chemosynthetic communities recommended by NTL 2009-G40 precludes the placement of a well within 610 m (2,000 ft) of any suspected site of a chemosynthetic community.

All known reserves in the Gulf of Mexico have specific gravity characteristics that would preclude oil from sinking immediately after release at a blowout site. As discussed in Chapter 4.3.1.5.4 of the Multisale EIS, oil discharges that occur at the seafloor from a pipeline or loss of well control would rise in the water column and surface almost directly over the source location, thus not impacting sensitive deepwater communities. Therefore, the oil is expected to rise to the sea surface under natural conditions. This behavior is modified when dispersants are applied to the oil on the sea surface or at depth, causing the oil to mix with water. The dispersed oil then begins to biodegrade and may flocculate with particulate matter in the water column, promoting sinking of the particles. The potential for weathered components from a surface slick, not treated with dispersants, to reach a deepwater community in any measurable volume would be very small.

Studies indicate that periods as long as hundreds of years are required to reestablish a chemosynthetic seep community once it has disappeared (depending on the community type); although it may reappear relatively quickly once the process begins, as in the case of a mussel community. Tube-worm communities may be the most sensitive of all communities because of the combined requirements of hard substrate and active hydrocarbon seepage. Mature tube-worm bushes have been found to be several hundred years old. There is evidence that substantial impacts on these communities could permanently prevent reestablishment, particularly if hard substrate required for recolonization was buried.

Proposed Action Analysis

For water depths >300 m (984 ft), 85-102 blowouts are estimated for the CPA proposed action over the 2007-2046 period (Table 4-6 of the Multisale EIS). The application of avoidance criteria for chemosynthetic communities recommended by NTL 2009-G40 should preclude any impact from a blowout at a minimum distance of 610 m (2,000 ft), which is beyond the distance of expected benthic disturbance. Resuspended bottom sediments transported by near-bottom currents could reach chemosynthetic communities located beyond 610 m (2,000 ft) and potentially impact them by burial or smothering. Oil treated with dispersant on the sea surface or at depth can mix with the water column and be carried by currents to contact chemosynthetic communities.

The risk of various sizes of oil spills occurring in the CPA is presented in **Table 3-5** . The possibility of a spill >10,000 bbl in the CPA is estimated to be up to one spill in the 40-year period for the proposed action. The possibility of oil from a surface spill reaching depth of 300 m (984 ft) or greater in any measurable concentration is very small. A catastrophic spill, like the DWH event, could affect chemosynthetic community habitat if dispersants are applied on the sea surface or at depth. The dispersed oil would be suspended in the water column and would begin to flocculate with particulate matter until it becomes heavy enough to sink and contact the seafloor. Since oil plumes would be carried by underwater currents, the impacts would be distributed in a line from the source toward the direction that the water currents travel. Oil plumes reaching chemosynthetic communities could cause oiling of organisms, resulting in the death of entire populations on localized sensitive habitats. These potential impacts would be localized due to the directional movement of oil plumes by the water currents and because the sensitive habitats have a scattered, patchy distribution. Habitats directly in the path of the oil plume when the oil contacts the seafloor would be affected. In addition, sublethal effects are possible for communities that receive a lower level of impact. These effects could include temporary lack of feeding, expenditure of energy to remove the oil, loss of gametes and reproductive delays, loss of tissue mass, and similar effects.

Summary and Conclusion

Chemosynthetic communities could be susceptible to physical impacts from a blowout depending on bottom-current conditions. The guidance provided in NTL 2009-G40 greatly reduce the risk of these

physical impacts. It clarifies the requirement to avoid potential chemosynthetic communities identified on the required geophysical survey records or photodocumentation to establish the absence of chemosynthetic communities prior to approval of the structure emplacement.

Studies indicate that periods as long as hundreds of years are required to reestablish a seep community once it has disappeared (depending on the community type). There is evidence that substantial impacts on these communities could permanently prevent reestablishment, particularly if hard substrate required for recolonization was buried by resuspended sediments from a blowout.

Potential accidental impacts from the CPA proposed action are expected to cause little damage to the ecological function or biological productivity of widespread, low-density chemosynthetic communities. The rarer, widely scattered, high-density, Bush Hill-type chemosynthetic communities located at more than 610 m (2,000 ft) away from a blowout could experience minor impacts from resuspended sediments. However, the possibility of oil from a surface spill reaching depth of 300 m (984 ft) or greater in any measurable concentration is very small. If dispersants are applied to an oil spill, oil would mix into the water column, be carried by underwater currents, and eventually contact the seafloor where it may impact patches of chemosynthetic community habitat in its path.

The BOEMRE has reexamined the analysis for impacts to chemosynthetic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found to indicate that accidental impacts associated with the CPA proposed action would result in more than minimal impacts to chemosynthetic communities because of the NTL 2009-G40 guidelines. One exception would be in the case of a catastrophic spill combined with the application of dispersant, producing the potential to cause devastating effects on local patches of habitat in the path of subsea plumes where they contact the seafloor.

4.1.1.9.4. Cumulative Impacts

Background/Introduction

A detailed description of cumulative impacts upon deepwater benthic communities of the CPA can be found in Chapter 4.5.4.2 of the Multisale EIS and in Chapter 4.1.5.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Cumulative factors considered to impact the deepwater benthic communities of the Gulf of Mexico include both oil- and gas-related and non-oil- and non-gas-related activities. The latter type of impacting factors includes activities such as fishing and trawling at a relatively small scale, and large-scale factors such as storm impacts and climate change.

There are essentially only three fish (or “shellfish”) species considered important to deepwater commercial bottom fisheries—the yellowedge grouper, tilefish, and royal red shrimp. Each of these is discussed in Chapter 4.5.4.2 of the Multisale EIS. Unlike other areas in the Atlantic and in Europe, bottom fishing and trawling efforts in the deeper water of the CPA are currently minimal, and impacts to deepwater benthic communities are negligible.

Other regional non-oil- and non-gas-related sources of cumulative impact to deepwater benthic communities would be possible, but they are considered unlikely to occur. Essentially no anchoring from non-OCS-related activities occurs at the deeper water depths considered for these resources (>300 m; 984 ft). Some impacts are highly unlikely yet not impossible, such as the sinking of a ship or barge resulting in collision or contaminant release directly on top of a sensitive, high-density chemosynthetic community.

One potential significant, large-scale source of impact could be potential efforts of carbon sequestration in the deep sea as a technique to reduce atmospheric carbon dioxide. This concept is still being considered but has major ramifications. One side of the issue, even beyond the problems of sea-level increase and climate change, includes the serious risk to shallow-water benthic organisms through pH increases, particularly those with calcium carbonate shells and skeletons (e.g., corals, serpulid worms, bryozoa, calcareous algae, etc) (Kleypas et al., 1999b; Barry et al., 2005; Shirayama and Thornton, 2005). However, the impacts of even very small excursions of pH and CO_2 in the deep sea could also have serious, even global, deep-sea ecosystem impacts. Kita and Ohsumi (2004) suggest sequestration of anthropogenic CO_2 could help reduce atmospheric CO_2, but they also summarize the potentially substantial biological impact on marine organisms. The issue continues to gain attention with the

increased emphasis on climate change. Scientists suggested in the August 2006 issue of the *Proceedings of the National Academy of Sciences* that thousands of years of the Nation's carbon emissions could be stored in undersea sediments along the coasts (Zenz House et al., 2006). A similar plan has been promoted by a private corporation to spread large amounts of nitrogen fertilizer in low-productive tropical waters (Maden and Nevala, 2008). Such a plan needs further thought since nutrients in urban runoff to tropical seas are considered to be a major contributor to the decline of coral reefs. Substantial additional research is needed before any large-scale actions would take place.

The greatest potential for cumulative adverse impacts to occur to the deepwater benthic communities would come from those OCS-related, bottom-disturbing activities associated with pipeline and platform emplacement (including templates and subsea completions), associated anchoring activities, discharges of muds and cuttings, and seafloor blowout accidents. The potential impacts to deepwater benthic communities from these activities were discussed in detail in Chapter 4.5.4.2 of the Multisale EIS.

As exploration and development continue on the Federal OCS, activities have moved farther into the deeper water areas of the Gulf of Mexico. With this trend comes the certainty that increased development would occur on discoveries throughout the entire depth range of the CPA; these activities would be accompanied by limited unavoidable impacts to the soft-bottom deepwater benthos from bottom disturbances and disruption of the seafloor from associated activities. The extent of these disturbances would be determined by the intensity of development in these deepwater regions, the types of structures and mooring systems used, and the effective application of the avoidance criteria as described in NTL 2009-G40 (USDOI, MMS, 2009c). All activity levels for the cumulative scenario in the CPA are shown in Table 4-6 of the Multisale EIS. For the CPA deepwater offshore Subareas C200-400, C400-800 C800-1600, C1600-2400, and C>2400, there are currently an estimated 39-84 exploration and delineation wells and 253-458 development wells to be drilled and 10-16 production structures to be installed through the 40-year analysis period (**Table 3-2**).

Routine discharges of drilling muds and cuttings have been documented to reach the seafloor in water depths >300 m (984 ft) and the impacts have been analyzed in the Multisale EIS, including the results from a study by CSA (2006b), *Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico*. Potential local cumulative impacts could result from accumulations of muds and cuttings resulting from consistent hydrographic conditions and drilling of multiple wells from the same location, causing concentrations of material in a single direction or "splay." It is not expected that detectable levels of muds and cuttings discharges from separate developments or from adjacent lease blocks would act as a cumulative impact to deepwater benthic communities, due to their physical separation and great water depths.

Numerous new chemosynthetic communities were discovered and explored using the submersible *Alvin* in 2006 and with the remotely operated vehicle *Jason II* in 2007 as part of the recent Agency-funded study, *Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico: Interim Report 2* (Brooks et al., 2009). These new communities were targeted using the same procedures integral to the biological review process and the use of NTL 2009-G40 targeting areas of potential community areas to be avoided by impacting oil and gas activities. There is no reason to expect an increased vulnerability of these deep communities to cumulative impacts.

A blowout at the seafloor could resuspend large quantities of bottom sediments and even create a large crater, destroying any organisms in the area. Structure removals and other bottom-disturbing activities could resuspend bottom sediments, but not at magnitudes as great as blowout events. Subsea structure removals are not expected in water depths >800 m (2,625 ft), in accordance with 30 CFR 250. The distance of separation provided by adherence to the guidelines of NTL 2009-G40 would protect chemosynthetic communities from sedimentation effects of deepwater blowouts. It is reported that chemically dispersed surface oil from the DWH event remained in the top 6 m (20 ft) of the water column where it mixed with surrounding waters and biodegraded (Lubchenco et al., 2010). Data from other studies on dispersant usage on surface plumes indicate that a majority of the dispersed oil remained in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (7 ft) (McAuliffe et al., 1981a). Therefore, oil spills on the sea surface are expected to have little to no effect on deepwater communities.

Subsea oil plumes resulting from a seafloor blowout could affect sensitive deepwater communities. This is especially true if dispersants are applied at depth. A recent report documents damage to a deepwater coral community in an area that oil plume models predicted as the direction of travel for subsea

oil plumes from the DWH event. Results are still pending but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts (USDOI, BOEMRE, 2010j). Such blowouts are rare and may not release catastrophic quantities of oil. Oil that is released would be carried in whatever direction the water currents flow. This directional flow could only affect seafloor habitats that are downstream from the source. Sensitive deepwater communities appear to be widely scattered and not as rare as previously expected. Recent BOEMRE analyses of seafloor remote-sensing data indicate over 15,000 locations in the deep GOM that represent potential hard-bottom habitats. While it is likely that any subsea oil plume traveling more than a few miles on the deep seafloor would encounter at least one of these potential habitats, it would result in a localized effect that is not expected to alter the wider population of the GOM.

In cases where high-density communities are subjected to greatly dispersed cumulative discharges or suspended sediments, the impacts are most likely to be sublethal in nature and limited in areal extent. The impacts to ecological function of high-density communities would be minor; minor impacts to ecological relationships with the surrounding benthos would also be likely.

Because of the great water depths, treated sanitary wastes and produced waters are not expected to have any adverse cumulative impacts to any deepwater benthic communities. These effluents would undergo a great deal of dilution and dispersion before reaching the bottom, if ever.

Oil and chemical spills (potentially from non-OCS-related activities) are not considered to be a potential source of measurable impacts on any deepwater communities because of water depth. Oil spills from the surface would tend to float. Oil discharges at depth or on the bottom would tend to rise in the water column and similarly not impact the benthos unless dispersants are applied at depth.

Deepwater coral and other hard-bottom communities not associated with chemosynthetic communities are also expected to be protected from cumulative impacts by general adherence to guidance described in NTL 2009-G40 and the shallow hazards NTL 2008-G05, due to the avoidance of areas represented as hard bottom on surface anomaly maps derived from 3D seismic records (USDOI, MMS, 2008c and 2009c). Biological reviews are performed on all deepwater plans (exploration and production) and pipeline applications, which include an analysis of maps and the avoidance of hard-bottom areas that are also one of several important indicators for the potential presence of chemosynthetic communities.

Summary and Conclusion

Cumulative impacts to deepwater communities in the Gulf of Mexico from sources other than OCS activities are considered negligible. The most serious, impact-producing factor threatening chemosynthetic communities is physical disturbance of the seafloor, which could destroy the organisms of these communities. Such disturbance would most likely come from those OCS-related activities associated with pipelaying, anchoring, structure emplacement, and seafloor blowouts. Drilling discharges and resuspended sediments have a potential to cause minor, mostly sublethal impacts to chemosynthetic communities, but substantial accumulations could result in more serious impacts. Seafloor disturbance is considered to be a threat only to the high-density communities; widely distributed low-density communities would not be at risk. Possible catastrophic oil spills due to seafloor blowouts have the potential to devastate localized deepwater benthic habitats. However, these events are rare and would only affect a small portion of the sensitive benthic habitat in the GOM. Recent analyses reveal over 15,000 possible hard-bottom locations across the deepwater GOM. Guidance provided in NTL 2009-G40 describes required surveys and avoidance prior to drilling or pipeline installation and would greatly reduce risk. New studies have refined predictive information and confirmed the effectiveness of these provisions throughout all depth ranges of the Gulf of Mexico (Brooks et al., 2009). With the dramatic success of this project, confidence is increasing regarding the use of geophysical signatures for the prediction of chemosynthetic communities.

Activities unrelated to the OCS Program include fishing and trawling. Because of the water depths in these areas (>300 m; 984 ft) and the low density of potentially commercially valuable fishery species, these activities are not expected to impact deepwater benthic comminutes. Regionwide and even global impacts from CO_2 build-up and proposed methods to sequester carbon in the deep sea (e.g., ocean fertilization) are not expected to have major impacts to deepwater habitats in the near future. More distant scenarios could include severe impacts.

The proposed activities in the CPA considered under the cumulative scenario are expected to cause little damage to the ecological function or biological productivity of the widespread, low-density chemosynthetic communities. The rarer, widely scattered, high-density, Bush Hill-type chemosynthetic communities could experience isolated minor impacts from drilling discharges or resuspended sediments, with recovery expected within several years, but even minor impacts are not expected. Major impacts to localized benthic habitat are possible in the event of a catastrophic blowout on the seafloor. If physical disturbance (such as anchor damage) or extensive burial by muds and cuttings were to occur to high-density, Bush Hill-type communities, impacts could be severe, with recovery time as long as 200 years for mature tube-worm communities. There is evidence that substantial impacts on these communities would permanently prevent reestablishment. The severity of such an impact is such that there would be incremental losses of productivity, reproduction, community relationships, overall ecological functions of the community, and incremental damage to ecological relationships with the surrounding benthos.

The incremental contribution of the CPA proposed action to cumulative impacts is expected to be slight and to result from the effects of the possible impacts caused by physical disturbance of the seafloor and minor impacts from sediment resuspension or drill cutting discharges. Adverse impacts would be limited but not completely eliminated by adherence to guidelines in NTL 2009-G40.

4.1.1.10. Nonchemosynthetic Deepwater Benthic Communities

4.1.1.10.1. Description of the Affected Environment

A description of the continental slope and deepwater resources can be found in the introduction to chemosynthetic communities in **Chapter 4.1.1.9** of this Supplemental EIS and in Chapter 3.2.2.2 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS can be found in Chapter 4.1.5.1 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the Supplemental EIS, and new information that has become available since both documents were prepared.

Deepwater Coral Benthic Communities

Deepwater corals are relatively rare examples of deepwater communities that would not be expected considering the fact that the vast majority of the deep GOM continental slope is made up of soft silt and clay sediments. Hermatypic (reef-building) corals contain photosynthetic algae and cannot live in deepwater environments; however, many ahermatypic corals can live on suitable substrates (hardgrounds) in these environments. Scleractinian corals are recognized in deepwater habitats, but there is little information regarding their distribution or abundance in the Gulf (USDOI, MMS, 2000, p. IV-14). Scleractinian corals may occupy isolated hard-bottom habitats but usually occur in association with high-density chemosynthetic communities that often are situated on carbonate hardgrounds.

Deepwater coral communities are now known to occur in many locations in the deep GOM (>300 m; 984 ft); one example is represented by what was reported as a deepwater coral reef by Moore and Bullis (1960). In an area measuring 300 m (984 ft) in length and more than 20 nmi (23 mi; 37 km) from the nearest known chemosynthetic community (likely in Viosca Knoll Block 906), a 1955 trawl collection from a depth of 421-512 m (1,381-1,680 ft) retrieved more than 300 lb (136 kg) of the scleractinian coral *Lophelia pertusa*.

The "rediscovery" of the Moore and Bullis site was notable. Prior to a *NR 1* Navy submersible cruise in 2002, there was a need to identify potential study sites for deepwater corals. The location sampled by Moore and Bullis had not been revisited since their trawl in 1955. The rough location given in their paper (29°5' N. latitude, 88°19' W. longitude; Moore and Bullis, 1960) was located in a soft-bottom environment. A biologist with BOEMRE used this location as a starting point and utilized the BOEMRE in-house 3D seismic database depicting seafloor bathymetry and hard-bottom features in the region. Approximately 5 nmi (6 mi; 9 km) to the west of the published location, there was a striking set of features including a narrow canyon that closely matched the fathometer tracing and depth of a feature illustrated in Moore and Bullis (1960). A number of potential high-reflectivity target locations across the canyon were provided for the *NR 1* project. Although no *Lophelia* coral was found in the canyon, a spectacular habitat including *Lophelia* and a variety of antipatharian "black corals" (some up to 3 m (9.8

ft) in height) was found while investigating the shallowest of the hard-bottom features located nearby in Viosca Knoll Block 862. It is not known if this peak was along the Moore and Bullis trawl track.

A large coral community (*L. pertusa*) was also discovered in Viosca Knoll Block 826 at a depth of 434 m (1,424 ft) by LGL Ecological Research Associates, Inc. while doing a chemosynthetic community environmental survey for Oryx Energy in 1990 (LGL Ecological Research Associates, Inc., 1990). Individual coral colonies at this site attain 1.5-2 m (5-7 ft) in height and width and up to 3-4 m (10-13 ft) in length. A large portion of the coral colonies are living. It was subsequently studied by submersible in the following years, 1991 and 1992, as well as numerous occasions since and is described in detail in Schroeder (2002). These deepwater coral habitats have since been shown to be much more extensive and important to the support of diverse communities of associated fauna than previously known in the GOM. This community in Viosca Knoll Block 826 remains the largest and best developed *Lophelia* community known in the northern GOM. This type of unusual and unexpected community may exist in many other areas of the deep GOM. Although *Lophelia* is best represented in water depths of the upper slope, it has been reported as deep as 3,000 m (9,842 ft) in some parts of the world. Additional studies funded by BOEMRE are in progress or in earlier stages of development that will further investigate the distribution of deepwater corals and other important nonchemosynthetic communities in the deep GOM.

As described previously, hard substrate originating from the Florida Escarpment appears to be exposed both at the upper crest of the escarpment at a depth of 1,600 m (5,248 ft) as well as an accumulation of probable talus at the bottom of the escarpment at a depth of 2,800 m (9,184 ft). If these reflective targets from 3D seismic are indeed exposed hard substrate, they could very possibly be colonized by a variety of deep-sea organisms including scleractinian corals. Although deeper than the high-density colonies of the upper slope, these depths are not prohibitive to a variety of coral development, including *Lophelia* and *Madrepora*. A relatively large accumulation of *Madrepora* was discovered during the recent Agency-funded study "Chemo III" in Green Canyon Block 852 at a depth of 1,448 m (4,749 ft), very similar to the depth of the top of the escarpment (Brooks et al., 2009). Considering the depth of this resource, >300 m (984 ft), these deepwater communities would be beyond the impacts from severe storms or hurricanes, and there has been no alteration of these communities caused from surface storms, including the severe hurricane season of 2005.

Deepwater Horizon Event

The DWH event released an estimated 4.9 million bbl of oil into the water over a period of 87 days. Extensive literature, Internet, and database searches have been conducted for results of scientific data. Although many research cruises have occurred, very few scientific results have been published as of this writing. Descriptions of studies completed or in progress are discussed in the previous section on chemosynthetic communities (**Chapter 4.1.1.9**). Possible impacts to nonchemosynthetic communities are discussed below.

Much of the oil was treated with dispersant at the sea surface and at the source in 1,500-m (5,000-ft) water depth. The dispersed oil mixed with the water; its movement was dictated by water currents and the physical processes of degradation. A full discussion of the fate and behavior of oil from the DWH event on chemosynthetic communities can be found in **Chapter 4.1.1.9**. Depending on how long it remained in the water column, oil may have been well-dispersed and thoroughly degraded by biological action before contact with the seafloor.

There have been no experiments showing the response of deepwater corals to oil exposure. Experiments with shallow tropical corals indicate that corals have a high tolerance to oil exposure. The mucus layers on coral resist penetration of oil and slough off the contaminant. Longer exposure times and areas of tissue where oil adheres to the coral are more likely to result in tissue damage and death of polyps. Corals with branching growth forms appear to be more susceptible to damage from oil exposure (Shigenaka, 2001). The most common deepwater coral, *Lophelia pertusa*, is a branching species. Tests with shallow tropical gorgonians indicate relatively low toxic effects to the coral, suggesting deepwater gorgonians may have a similar response (Cohen et al., 1977). Deepwater coral response to exposure to oil from the DWH event would vary, depending on the level of exposure. A recent report documents damage to a deepwater coral community in an area that oil plume models predict as the direction of travel for subsea oil plumes from the DWH event. Results are still pending but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts

(USDOI, BOEMRE, 2010j). Coral forms structures that protrude up into the water column above the seafloor, making them more susceptible to impacts from a passing oil plume. Research projects are continuing to investigate areas around the DWH event to assess the impacts.

Communities exposed to concentrated oil may have experienced detrimental effects including death of affected organisms, tissue damage, lack of growth, interruption of reproductive cycles, and loss of gametes. Median levels of exposure to dispersed oil in a partly degraded condition may have resulted in effects similar to those for shallow tropical corals, with often no discernable effects other than temporary contraction and some sloughing. Exposure to widely dispersed oil adhering to organic detritus and partially degraded by bacteria may be expected to result in little effect. Health of corals may have been degraded by the necessary expenditure of energy as the corals respond to oiling, Coral exposure to lower concentrations of oil may have resulted in sublethal impacts such as altered reproduction, growth, respiration, excretion, chemoreception, feeding, movement, stimulus response, and susceptibility to disease (Suchanek, 1993). Many invertebrates associated with deepwater coral communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure. Recolonization of severely damaged or destroyed communities could take years to decades.

4.1.1.10.2. Impacts of Routine Events

Background/Introduction

A detailed description of the possible impacts from routine activities associated with the CPA proposed action on nonchemosynthetic communities is presented in Chapter 4.2.2.1.4.2.2 of the Multisale EIS and in Chapter 4.1.5.2.2 of the 2009-2012 Supplemental EIS. Similar to chemosynthetic communities, benthic communities other than chemosynthetic organisms could be impacted by physical impacts from drilling discharges, structure placement (including templates or subsea completions), anchoring, or pipeline installation.

Both widespread soft-bottom and rare hard-bottom, nonchemosynthetic deepwater benthic communities are susceptible to physical impacts from drilling discharges, structure placement (including templates or subsea completions), anchoring, and pipeline installation. In deep water as opposed to shallower areas on the continental shelf, discharges of drilling fluids and cuttings at the surface are spread across broader areas of the seafloor and are generally distributed in thinner accumulations. Carbonate outcrops and deepwater coral communities not associated with chemosynthetic communities are considered to be most at risk from oil and gas operations.

The physical disturbances by structures themselves are typically limited to anchors for holding floating drilling or production facilities over the well sites. Anchoring would not necessarily directly destroy small infaunal organisms living within the sediment. The bottom disturbance would most likely change the environment to such an extent that the majority of the directly impacted infauna community would not survive (e.g., burial or relocation to sediment layers without sufficient oxygen), but adjacent populations of all size classes of organisms would quickly repopulate the modified sediment. In addition, increased surface roughness (rugosity) resulting from anchor or related disturbance of mud bottom would positively impact the habitat value for many infaunal and epifaunal groups as a result of increased habitat complexity. In cases of carbonate outcrops or reefs with attached epifauna or coral, the impacted area of disturbance may be small in absolute terms, but it could be a large portion of the local area inhabited by fragile hard corals or other organisms that rely on exposed hard substrate. Anchors from support boats and ships (or any buoys set out to moor vessels), floating drilling units, barges used for the construction of platform structures, pipelaying vessels, and pipeline repair vessels could also cause severe disturbances to small areas of the seafloor.

Normal pipelaying activities in deepwater areas could impact areas of hard-bottom nonchemosynthetic organisms if they were crossed by the pipeline (pipeline burial is not required at depths where deepwater hard-bottom communities are found). Impacts of pipeline contact on soft bottom would be minimal.

Proposed Action Analysis

The routine activities associated with the CPA proposed action that would impact nonchemosynthetic benthic communities would come from activities associated with drilling discharges, structure placement

(including templates or subsea completions), anchoring, or pipeline installation. For the CPA proposed action, 10-16 production structures ranging from small subsea developments to large developments involving floating, fixed, or subsea structures are estimated to be installed during the 40-year analysis period in Subareas C200-400 C400-800, C800-1600, C1600-2400, and C>2400 m (**Table 3-2**). Drilling muds and cuttings discharged at the seafloor or from the surface would have some limited impact to soft-bottom communities at or below the sediment/water interface. The surface discharge of muds and cuttings in deeper water would reduce or eliminate the impact of smothering the benthic communities on the bottom due to increased dispersal. Even in situations where the substantial burial of typical benthic infaunal communities occurred, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms. An additional analysis of muds and cuttings discharge impacts appears in Chapter 4.1.1.4.1 of the Multisale EIS.

Physical disturbance or destruction of a limited area of benthos or to a limited number of megafauna organisms such as brittle stars, sea pens, or crabs would not result in a major impact to the deepwater benthos ecosystem as a whole. Under the current review procedures for chemosynthetic communities as described in NTL 2009-G40, carbonate outcrops are targeted as one possible indication (surface amplitude anomaly on 3D seismic survey data) of the presence of chemosynthetic seep communities. Unique communities that may be associated with any carbonate outcrops or other topographical features can be identified via this review, along with the chemosynthetic communities. Typically, all areas suspected of being hard bottom are avoided as geological hazards for any well sites. Any proposed activity in water depths >300 m (984 ft) would automatically trigger the NTL 2009-G40 evaluation described above.

The impacts of pipeline contact on soft bottom would be minimal because pipeline burial is not required in water depths <61 m (200 ft). Hard-bottom areas would be avoided for the same reasons described above.

With the CPA proposed action, when geophysical survey information indicates the potential presence of chemosynthetic communities, the biological review process and use of NTL 2009-G40 would apply. This would result in a greatly reduced probability of any impacts occurring.

Summary and Conclusion

Some impact to soft-bottom benthic communities from drilling and production activities would occur as a result of physical impact from drilling discharges, structure placement (including templates or subsea completions), anchoring, and installation of pipelines regardless of their locations. However, even in situations where the substantial burial of typical benthic infaunal communities occurred, recolonization from populations from widespread neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms.

Impacts to other hard-bottom communities are expected to be avoided as a consequence of the application of the existing NTL 2009-G40 guidelines for chemosynthetic communities. The same geophysical conditions associated with the potential presence of chemosynthetic communities also results in the potential occurrence of hard carbonate substrate and nonchemosynthetic communities. Because of the NTL 2009-G40 guidelines, these are generally avoided in exploration and development planning.

The BOEMRE has reexamined the analysis for impacts to nonchemosynthetic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found that would alter the overall conclusion that impacts on nonchemosynthetic communities from routine activities associated with the CPA proposed action would be minimal to none.

4.1.1.10.3. Impacts of Accidental Events

Background/Introduction

A detailed description of accidental impacts upon nonchemosynthetic, deepwater benthic communities can be found in Chapter 4.4.4.2.2 of the Multisale EIS and in Chapter 4.1.5.3.2 of the 2009-2012 Supplemental EIS. The following is a summary of that information with consideration of new information found since publication of the Multisale EIS and the 2009-2012 Supplemental EIS.

Accidental events that could impact nonchemosynthetic deepwater benthic communities are primarily limited to seafloor blowouts. Surface oil and chemical spills are not considered to be a potential source of measurable impacts on nonchemosynthetic communities because of the water depths at which these communities are located. A blowout at the seafloor could create a crater and could resuspend and disperse large quantities of bottom sediments within a 300-m (984-ft) radius from the blowout site. This would destroy any organisms located within that distance by burial or modification of narrow habitat quality requirements. Physical disturbance or destruction of a limited area of benthos or to a limited number of megafauna organisms (e.g. brittle stars, sea pens, and crabs) would not result in a major impact to the deepwater benthos ecosystem as a whole or even in relation to a small area of the seabed within a lease block. The application of avoidance criteria for deepwater coral communities recommended by NTL 2009-G40 precludes the placement of a well within 610 m (2,000 ft) of any suspected site of a deepwater coral community.

All known reserves in the Gulf of Mexico have specific gravity characteristics that would preclude oil from sinking immediately after release at a blowout site. As discussed in Chapter 4.3.1.5.4 of the Multisale EIS, oil discharges that occur at the seafloor from a pipeline or loss of well control would rise in the water column and surface almost directly over the source location, thus not impacting sensitive deepwater communities. Therefore, the oil is expected to rise to the sea surface under natural conditions. This behavior is modified when dispersants are applied to the oil on the sea surface or at depth, causing the oil to mix with water. The dispersed oil then begins to biodegrade and may flocculate with particulate matter in the water column, promoting sinking of the particles. The potential for weathered components from a surface slick, not treated with dispersants, to reach a deepwater community in any measurable volume would be very small.

Deepwater coral habitats and other potential hard-bottom communities not associated with chemosynthetic communities appear to be relatively rare. Any hard substrate communities located in deep water would be particularly sensitive to impacts. Impacts to these sensitive habitats could permanently prevent recolonization, with similar organisms requiring hard substrate. Adherence to the guidance provided in NTL 2009-G40 should prevent all but minor impacts to hard-bottom communities located the prescribed distance of more than 610 m (2,000 ft) from a well site. Under the current review procedures, carbonate outcrops (high reflectivity surface anomalies on 3D seismic survey data) are targeted as one possible indication that sensitive hard-bottom communities are present. Typically, all areas suspected of being hard bottom are avoided as a potential geological hazard for any well sites. Any proposed impacting activity in water depths >300 m (984 ft) would automatically trigger the NTL 2009-G40 evaluation described above.

Proposed Action Analysis

For water depths >300 m (984 ft), 85-102 blowouts are estimated for the CPA proposed action over the 2007-2046 period (Table 4-6 of the Multisale EIS). Resuspended sediments caused from a blowout would have minimal impacts on the full spectrum of soft-bottom community animals, including the possible mortality of a few megafauna specimens such as crab or shrimp. The application of avoidance criteria for sensitive deepwater communities recommended by NTL 2009-G40 should preclude a blowout from affecting hard-bottom communities located the prescribed distance of more than 609 m (2,000 ft) from a well site.

The risk of various sizes of oil spills occurring in the CPA is presented in **Table 3-5** . The possibility of a spill >10,000 bbl in the CPA is estimated to be up to one spill during in the 40-year life of the proposed action. The possibility of oil from a surface spill reaching depths of 300 m (984 ft) or greater in any measurable concentration is very small. A catastrophic spill, like the DWH event, could affect nonchemosynthetic community habitat if dispersants are applied on the sea surface or at depth. The dispersed oil would be suspended in the water column and would begin to flocculate with particulate matter until it becomes heavy enough to sink and contact the seafloor. Since oil plumes would be carried by underwater currents, the impacts would be distributed in a line from the source toward the direction that the water currents travel. Oil plumes reaching nonchemosynthetic communities could cause oiling of organisms resulting in the death of entire populations on localized sensitive habitats. These potential impacts would be localized due to the directional movement of oil plumes by the water currents and because the sensitive habitats have a scattered, patchy distribution. Habitats directly in the path of the oil

plume when the oil contacts the seafloor would be affected. In addition, sublethal effects are possible for communities that receive a lower level of impact. These effects could include temporary lack of feeding, expenditure of energy to remove the oil, loss of gametes and reproductive delays, loss of tissue mass, and similar effects.

Summary and Conclusion

Accidental events resulting from the CPA proposed action are expected to cause little damage to the ecological function or biological productivity of widespread, typical, deep-sea benthic communities. Some impact to benthic communities would occur as a result of impact from an accidental blowout. Megafauna and infauna communities at or below the sediment/water interface would be impacted by the physical disturbance of a blowout or by burial from resuspended sediments. However, even in situations where the substantial burial of typical soft benthic communities occurred, recolonization by populations from neighboring substrate would be expected over a relatively short period of time. For all size ranges of organisms, this can be in a matter of hours to days for bacteria and about 1-2 years for most all macrofauna species.

Impacts to deepwater coral habitats and other potential hard-bottom communities would likely be avoided as a consequence of the application of the policies described in NTL 2009-G40. The rare, widely scattered, high-density, Bush Hill-type nonchemosynthetic communities located at more than 610 m (2,000 ft) away from a blowout could experience minor impacts from resuspended sediments. If dispersants are applied to an oil spill oil would mix into the water column, be carried by underwater currents, and eventually contact the seafloor where it may impact patches of sensitive deepwater community habitat in its path. These potential impacts would be localized due to the directional movement of oil plumes by the water currents and because the sensitive habitats have a scattered, patchy distribution.

The BOEMRE has reexamined the analysis for impacts to nonchemosynthetic communities presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found to indicate that accidental impacts associated with the CPA proposed action would result in more than minimal impacts to nonchemosynthetic communities. One exception would be in the case of a catastrophic spill combined with the application of dispersant, producing the potential to cause devastating effects on local patches of habitat in the path of subsea plumes where they contact the seafloor.

4.1.1.10.4. Cumulative Impacts

Background/Introduction

A detailed description of cumulative impacts upon deepwater benthic communities of the CPA can be found in Chapter 4.5.4.2 of the Multisale EIS and in Chapter 4.1.5.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Cumulative factors considered to impact the deepwater benthic communities of the Gulf of Mexico include both oil- and gas-related and non-oil- and non-gas-related activities. The latter type of impacting factors includes activities such as fishing and trawling at a relatively small scale, and large-scale factors such as storm impacts and climate change.

There are essentially only three fish (or “shellfish”) species considered important to deepwater commercial bottom fisheries—the yellowedge grouper, tilefish, and royal red shrimp. Each of these is discussed in Chapter 4.5.4.2 of the Multisale EIS. Unlike other areas in the Atlantic and in Europe, bottom fishing and trawling efforts in the deeper water of the CPA are currently minimal, and impacts to deepwater benthic communities are negligible.

Other regional non-oil- and non-gas-related sources of cumulative impact to deepwater benthic communities would be possible, but they are considered unlikely to occur. Essentially no anchoring from non-OCS-related activities occurs at the deeper water depths considered for these resources (>300 m; 984 ft). Some impacts are highly unlikely yet not impossible, such as the sinking of a ship or barge resulting in collision or contaminant release directly on top of a sensitive, high-density nonchemosynthetic community.

One potential significant large-scale source of impact could be potential efforts of carbon sequestration in the deep sea as a technique to reduce atmospheric carbon dioxide. This concept is still being considered but has major ramifications. One side of the issue, even beyond the problems of sea-level increase and climate change, includes the serious risk to shallow-water benthic organisms through pH increases, particularly those with calcium carbonate shells and skeletons (e.g., corals, serpulid worms, bryozoa, calcareous algae, etc) (Kleypas et al., 1999b; Barry et al., 2005; Shirayama and Thornton, 2005). However, the impacts of even very small excursions of pH and CO_2 in the deep sea could also have serious, even global, deep-sea ecosystem impacts. Kita and Ohsumi (2004) suggest sequestration of anthropogenic CO_2 could help reduce atmospheric CO_2, but they also summarize the potentially substantial biological impact on marine organisms. The issue continues to gain attention with the increased emphasis on climate change. Scientists suggested in the August 2006 issue of the *Proceedings of the National Academy of Sciences* that thousands of years of the Nation's carbon emissions could be stored in undersea sediments along the coasts (Zenz House et al., 2006). A similar plan has been promoted by a private corporation to spread large amounts of nitrogen fertilizer in low productive tropical waters (Maden and Nevala, 2008). Such a plan needs further thought since nutrients in urban runoff to tropical seas are considered to be a major contributor to the decline of coral reefs. Substantial additional research is needed before any large-scale actions would take place.

The greatest potential for cumulative adverse impacts to occur to the deepwater benthic communities would come from those OCS-related, bottom-disturbing activities associated with pipeline and platform emplacement (including templates and subsea completions), associated anchoring activities, discharges of muds and cuttings, and seafloor blowout accidents. The potential impacts to deepwater benthic communities from these activities were discussed in detail in Chapter 4.5.4.2 of the Multisale EIS.

As exploration and development continue on the Federal OCS, activities have moved farther into the deeper water areas of the Gulf of Mexico. With this trend comes the certainty that increased development would occur on discoveries throughout the entire depth range of the CPA; these activities would be accompanied by limited unavoidable impacts to the soft-bottom deepwater benthos from bottom disturbances and disruption of the seafloor from associated activities. The extent of these disturbances would be determined by the intensity of development in these deepwater regions, the types of structures and mooring systems used, and the effective application of the avoidance criteria as described in NTL 2009-G40 (USDOI, MMS, 2009c). All activity levels for the cumulative scenario in the CPA are shown in Table 4-6 of the Multisale EIS. For the CPA deepwater, offshore Subareas C200-400, C400-800, C800-1600, C1600-2400, and C>2400, there are currently an estimated 39-84 exploration and delineation wells and 253-458 development wells to be drilled and 10-16 production structures to be installed through the 40-year analysis period (**Table 3-2**).

Routine discharges of drilling muds and cuttings have been documented to reach the seafloor in water depths >300 m (984 ft) and the impacts have been analyzed in the Multisale EIS, including the results from a study by CSA (2006b), *Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico*. Potential local cumulative impacts could result from accumulations of muds and cuttings resulting from consistent hydrographic conditions and drilling of multiple wells from the same location causing concentrations of material in a single direction or "splay." It is not expected that detectable levels of muds and cuttings discharges from separate developments or from adjacent lease blocks would act as a cumulative impact to deepwater benthic communities due their physical separation and great water depths.

Numerous new deepwater communities were recently discovered and explored using the submersible *Alvin* in 2006 and with the remotely operated vehicle *Jason II* in 2007 as part of a new Agency-funded study (Brooks et al., 2009). These new communities were targeted using the same procedures integral to the biological review process and the use of NTL 2009-G40 targeting areas of potential community areas to be avoided by impacting oil and gas activities. There is no reason to expect an increased vulnerability of these deep communities to cumulative impacts.

A blowout at the seafloor could resuspend large quantities of bottom sediments and even create a large crater, destroying any organisms in the area. Structure removals and other bottom-disturbing activities could resuspend bottom sediments, but not at magnitudes as great as blowout events. Subsea structure removals are not expected in water depths >800 m (2,625 ft), in accordance with 30 CFR 250. The distance of separation provided by adherence to the guidelines of NTL 2009-G40 would protect nonchemosynthetic communities from sedimentation effects of deepwater blowouts. It is reported that

chemically dispersed surface oil from the DWH event remained in the top 6 m (20 ft) of the water column where it mixed with surrounding waters and biodegraded (Lubchenco et al., 2010). Data from other studies on dispersant usage on surface plumes indicate that a majority of the dispersed oil remained in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (7 ft) (McAuliffe et al., 1981a). Therefore, oil spills on the sea surface are expected to have little-to-no effect on deepwater communities.

Subsea oil plumes resulting from a seafloor blowout could affect sensitive deepwater communities. This is especially true if dispersants are applied at depth. A recent report documents damage to a deepwater coral community in an area that oil plume models predicted as the direction of travel for subsea oil plumes from the DWH event. Results are still pending but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged, possibly the result of oil impacts (USDOI, BOEMRE, 2010j). Such blowouts are rare and may not release catastrophic quantities of oil. Oil that is released would be carried in whatever direction the water currents flow. This directional flow could only affect seafloor habitats that are downstream from the source. Sensitive deepwater communities appear to be widely scattered and not as rare as previously expected. Recent BOEMRE analyses of seafloor remote-sensing data indicate over 15,000 locations in the deep GOM that represent potential hard-bottom habitats. While it is likely that any subsea oil plume traveling more than a few miles on the deep seafloor would encounter at least one of these potential habitats, it would result in a localized effect that is not expected to alter the wider population of the GOM.

In cases where high-density communities are subjected to greatly dispersed cumulative discharges or suspended sediments, the impacts are most likely to be sublethal in nature and limited in areal extent. The impacts to ecological function of high-density communities would be minor; minor impacts to ecological relationships with the surrounding benthos would also be likely.

Because of the great water depths, treated sanitary wastes and produced waters are not expected to have any adverse cumulative impacts to any deepwater benthic communities. These effluents would undergo a great deal of dilution and dispersion before reaching the bottom, if ever.

Oil and chemical spills (potentially from non-OCS-related activities) are not considered to be a potential source of measurable impacts on any deepwater communities because of water depth. Oil spills from the surface would tend to float. Oil discharges at depth or on the bottom would tend to rise in the water column and similarly not impact the benthos unless dispersants are applied at depth.

Deepwater coral and other hard-bottom communities not associated with nonchemosynthetic communities are also expected to be protected from cumulative impacts by general adherence to guidance described in NTL 2009-G40 and the shallow hazards NTL 2008-G05 due to the avoidance of areas represented as hard bottom on surface anomaly maps derived from 3D seismic records (USDOI, MMS, 2008c and 2009c). Biological reviews are performed on all deepwater plans (exploration and production) and pipeline applications, which include an analysis of maps and the avoidance of hard-bottom areas that are also one of several important indicators for the potential presence of nonchemosynthetic communities.

Summary and Conclusion

Cumulative impacts to deepwater communities in the Gulf of Mexico from sources other than OCS activities are considered negligible. The most serious, impact-producing factor threatening nonchemosynthetic communities is physical disturbance of the seafloor, which could destroy the organisms of these communities. Such disturbance would most likely come from those OCS-related activities associated with pipelaying, anchoring, structure emplacement, and seafloor blowouts. Drilling discharges and resuspended sediments have a potential to cause minor, mostly sublethal impacts to nonchemosynthetic communities, but substantial accumulations could result in more serious impacts. Seafloor disturbance is considered to be a threat only to the high-density communities; widely distributed low-density communities would not be at risk. Possible catastrophic oil spills due to seafloor blowouts have the potential to devastate localized deepwater benthic habitats. However, these events are rare and would only affect a small portion of the sensitive benthic habitat in the GOM. Recent analyses reveal over 15,000 possible hard-bottom locations across the deepwater GOM. However, because the guidance provided in NTL 2009-G40 describes required surveys and avoidance prior to drilling or pipeline installation, the risk would be greatly reduced. New studies have refined predictive information and confirmed the effectiveness of these provisions throughout all depth ranges of the Gulf of Mexico

(Brooks et al., 2009). With the dramatic success of this project, confidence is increasing regarding the use of geophysical signatures for the prediction of nonchemosynthetic communities.

Activities unrelated to the OCS Program include fishing and trawling. Because of the water depths in these areas (>300 m; 984 ft) and the low density of potentially commercially valuable fishery species, these activities are not expected to impact deepwater benthic comminutes. Regionwide and even global impacts from CO_2 build-up and proposed methods to sequester carbon in the deep sea (e.g., ocean fertilization) are not expected to have major impacts to deepwater habitats in the near future. More distant scenarios could include severe impacts.

The activities considered under the cumulative scenario are expected to cause little damage to the ecological function or biological productivity of the widespread, low-density deepwater communities. The rarer, widely scattered, high-density, Bush Hill-type communities could experience isolated minor impacts from drilling discharges or resuspended sediments, with recovery expected within several years, but even minor impacts are not expected. Major impacts to localized benthic habitat are possible in the event of a catastrophic blowout on the seafloor, but the probability of this occurring is low. If physical disturbance (such as anchor damage) or extensive burial by muds and cuttings were to occur to high-density, Bush Hill-type communities, impacts could be severe, with recovery time as long as 200 years for mature communities. There is evidence that substantial impacts on these communities would permanently prevent reestablishment. The severity of such an impact is such that there would be incremental losses of productivity, reproduction, community relationships, overall ecological functions of the community, and incremental damage to ecological relationships with the surrounding benthos. The possible impacts to these communities are decreased through BOEMRE's biological review process and the use of NTL 2009-G40, which physically distances petroleum-producing activities from sensitive deepwater benthic communities. The incremental contribution of the CPA proposed action to cumulative impacts is expected to be slight and to result from the effects of the possible impacts caused by physical disturbance of the seafloor and minor impacts from sediment resuspension or drill cutting discharges. Adverse impacts would be limited but not completely eliminated by adherence to guidelines in NTL 2009-G40.

4.1.1.11. Marine Mammals

The BOEMRE has reexamined the analysis of the 29 species of marine mammals occurring in the Gulf of Mexico presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for marine mammals presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Routine events related to the CPA proposed action, particularly when mitigated as required by BOEMRE, are not expected to have long-term adverse effects on the size and productivity of any marine mammal species or populations in the northern Gulf of Mexico. Characteristics of impacts from accidental events depend on chronic or acute exposure, resulting in harassment, harm, or mortality to marine mammals, while exposure to dispersed hydrocarbons is likely to result in sublethal impacts. The effects of the incremental contribution of the CPA proposed action, combined with non-OCS activities, may be deleterious to cetaceans occurring in the Gulf of Mexico. Biological significance of any mortality would depend, in part, on the size and reproductive rates of the affected stocks, as well as the number, age, and size of animals affected.

4.1.1.11.1. Description of the Affected Environment

A detailed description of marine mammals can be found in Chapter 3.2.3 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.6 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-

2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Twenty-nine species of marine mammals occur in the Gulf of Mexico (Davis et al., 2000). The Gulf of Mexico's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong. Within the Gulf of Mexico, there are 28 species of cetaceans (7 mysticete and 21 odontocete species) and 1 sirenian species, the manatee (Jefferson et al., 1992) (**Table 4-2**). The abundance estimates from **Table 4-2** are from NMFS's Gulf of Mexico Marine Mammal Stock Assessments (Waring, 2009). The best available stock assessment for manatees, which are under the jurisdiction of FWS, is cited from the Manatee Synoptic Aerial Survey Data (Florida Fish and Wildlife Conservation Commission, 2011). Seven remaining cetaceans (6 mysticete species—northern right whale, blue whale, fin whale, sei whale, minke whale, humpback whale and 1 odontocete species—Sowerby's beaked whale) have been observed in the GOM in the past, and therefore, there are stock assessments for these species. However, they are not considered resident GOM species and are therefore not included in **Table 4-2**. Chapter 3.2.3 of the Multisale EIS and Chapter 4.1.6 of the 2009-2012 Supplemental EIS provide further detail.

The most current and best available count of the Florida manatee population is 4,834 animals, based on a synoptic survey in January 2011 of warm-water refuges and adjacent areas (Florida Fish and Wildlife Conservation Commission, 2011).

The DWH event and resulting oil spill in Mississippi Canyon Block 252 and related spill-response activities may have impacted marine mammals that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected marine mammal environment. For the latest available information on oiled or affected marine mammals documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c). More detail on the potential range of effects to marine mammals from contact with spilled oil can be found in St. Aubin and Geraci (1990) and on the NMFS Office of Protected Resources website (http://www.nmfs.noaa.gov/pr/health/oilspill/mammals.htm).

A similar yet not comparable blowout of the *Ixtoc I* offshore drilling rig in the Bay of Campeche, Mexico on June 3, 1979, resulted in the release of 500 thousand metric tons (140 million gallons) and transport of this oil into the Gulf of Mexico (ERCO, 1982). The effect on marine mammals was undetermined.

Threatened and Endangered Species

Five baleen cetaceans (the northern right, blue, fin, sei, and humpback whales), one toothed cetacean (the sperm whale), and one sirenian (the West Indian manatee) occur in the Gulf of Mexico and are listed as endangered under the Endangered Species Act of 1973. The sperm whale is common in oceanic waters of the northern Gulf of Mexico and appears to be a resident species, while the baleen whales are considered rare or extralimital in the Gulf of Mexico (Würsig et al., 2000). The life history, population dynamics, status, distribution, behavior, and habitat use of baleen and toothed whales can be found in Chapters 3.2.3.1.1 and 3.2.3.1.2 of the Multisale EIS, respectively.

The West Indian manatee (*Trichechus manatus*) typically inhabits only coastal marine, brackish, and freshwater areas. The distribution, feeding habits, habitat use, and population estimates of manatees can be found in Chapter 3.2.3.1.3 of the Multisale EIS.

Additional research was conducted to investigate recently available information since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. Palka and Johnson (2007) present the results of a study that collected the dive patterns of sperm whales in the Atlantic Ocean to compare them with the dive patterns and social structure of sperm whales in the Gulf of Mexico. The study started a baseline of line transect, photo-identification, oceanographic, and genetic data for the Atlantic sperm whale. Compared with the Mississippi River Delta in the Gulf of Mexico, parts of the Atlantic Ocean may serve as a control population of sperm whales with little exposure to sounds of oil- and gas-related activities. The study found that Gulf of Mexico sperm whales follow a foraging and socializing cycle similar to that seen for the North Atlantic whales, but North Atlantic sperm whales dive significantly deeper (average 934 m (3,064 ft) compared with 639 m (2,096 ft) for Gulf of Mexico whales) when foraging (Palka and

Johnson, 2007). Jochens et al. (2008) published a synthesis of work conducted as the Sperm Whale Seismic Study in the Gulf of Mexico. Data from this study confirm that the GOM sperm whales constitute a genetically distinct stock from other Atlantic sperm whale stocks.

The NOAA recently published a final recovery plan for the sperm whale (USDOC, NMFS, 2010b), and current threats to sperm whale populations worldwide are discussed. Threats are defined as “any factor that could represent an impediment to recovery” and these include fisheries interactions, anthropogenic noise, vessel interactions, contaminants and pollutants, disease, injury from marine debris, research, predation and natural mortality, direct harvest, competition for resources, loss of prey base due to climate change and ecosystem change, and cable laying. In the GOM, the impacts from many of these threats are identified as either low or unknown.

Recent Consultation

As mandated by the ESA, BOEMRE consulted with NMFS and FWS on possible and potential impacts from the CPA or WPA proposed action on endangered/threatened species and designated critical habitat under their jurisdiction. A biological assessment was prepared for each consultation. The action area analyzed in the biological assessments included the lease sale areas addressed in this Supplemental EIS.

The formal ESA consultation with NMFS was concluded with receipt of the Biological Opinion on July 3, 2007 (USDOC, NMFS, 2007b). The Biological Opinion concludes that the proposed lease sales and associated activities in the Gulf of Mexico in the current 5-Year Program are not likely to jeopardize the continued existence of threatened and endangered species under NMFS jurisdiction or destroy or adversely modify designated critical habitat. The following information was present in the Biological Opinion, but not in the Multisale EIS. Based on NMFS’s surveys, opportunistic sightings, and stranding records, sperm whales in the Gulf of Mexico occur year-round. Sperm whales appear to favor water depths of about 1,000 m (3,281 ft) and appear to be concentrated in at least two geographic regions of the northern Gulf of Mexico: (1) an area off the Dry Tortugas and (2) offshore of the Mississippi River Delta (Maze-Foley and Mullin, 2006). However, distribution also appears influenced by occurrence and movement of cyclonic/anticyclonic currents in the Gulf of Mexico. The informal ESA consultation with FWS was concluded with a letter dated September 14, 2007. The FWS concurred with the BOEMRE determination that proposed actions of the current 5-Year Program were not likely to adversely affect the threatened/endangered species or designated critical habitat under FWS jurisdiction.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

Nonendangered Species

One baleen cetacean (Bryde’s whale) and 20 toothed cetaceans (including beaked whales and dolphins) occur in the Gulf of Mexico. The life history, population dynamics, status, distribution, behavior, and habitat use of the nonendangered baleen and toothed whales can be found in Chapters 3.2.3.2.1 and 3.2.3.2.2 of the Multisale EIS, respectively.

Factors Influencing Cetacean Distribution and Abundance

The distribution and abundance of cetaceans within the northern Gulf of Mexico is strongly influenced by various mesoscale oceanographic circulation patterns. These patterns are primarily driven by river discharge (primarily the Mississippi/Rivers), wind stress, and the Loop Current and its derived circulation phenomena. Circulation on the continental shelf is largely wind-driven, with localized effects

from freshwater (i.e., river) discharge. Beyond the shelf, mesoscale circulation is largely driven by the Loop Current in the eastern Gulf of Mexico. Approximately once or twice a year, the Loop Current sheds anticyclonic eddies (also called warm-core rings). Anticyclones are long-lived, dynamic features that generally migrate westward and transport large quantities of high-salinity, nutrient-poor water across the near-surface waters of the northern Gulf of Mexico. These anticyclones, in turn, spawn cyclonic eddies (also called cold-core rings) during interaction with one another and upon contact with topographic features of the continental slope and shelf edge. These cyclones contain and maintain high concentrations of nutrients and stimulate localized production (Davis et al., 2000). In the north-central Gulf of Mexico, the relatively narrow continental shelf south of the Mississippi River Delta may be an additional factor affecting cetacean distribution (Davis et al., 2000). Outflow from the mouth of the Mississippi River transports large volumes of low-salinity, nutrient-rich water southward across the continental shelf and over the slope. River outflow also may be entrained within the confluence of a cyclone-anticyclone eddy pair and transported beyond the continental slope. Marine predators such as the bottlenose dolphin focus their foraging efforts on these abundant prey locations to improve overall efficiency and reduce energy costs (Bailey and Thompson, 2010). This nutrient-rich input of water leads to a localized deepwater environment with enhanced productivity and may explain the persistent presence of aggregations of sperm whales within 31 mi (50 km) of the Mississippi River Delta in the vicinity of Mississippi Canyon.

4.1.1.11.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of the marine mammals for the CPA proposed action can be found in Chapter 4.2.2.1.5 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.6.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Potential effects on marine mammal species may occur from routine activities associated with the CPA proposed action and may be direct or indirect. The major potential impact-producing factors affecting marine mammals as a result of routine OCS activities include the degradation of water quality from operational discharges; noise generated by helicopters, vessels, operating platforms, and drillships; vessel traffic; explosive structure removals; seismic surveys; and marine debris from service vessels and OCS structures.

Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC, 1983; API, 1989; Kennicutt, 1995; Kennicutt et al., 1996). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al., 1989). Marine mammals generally are thought to be inefficient assimilators of petroleum compounds within prey (Neff, 1990). Although the scope and magnitude of such effects are not known, direct or indirect effects are not expected to be lethal.

Noise associated with the CPA proposed action, including drilling noise, aircraft, and vessels, may affect marine mammals by eliciting a startle response or by masking other underwater sounds necessary for proper feeding or reproductive success. Deep-diving whales may be more vulnerable to vessel strikes given the longer surface period required to recover from extended deep dives. Given that NMFS has determined vessel strikes to be a discountable concern for sperm whales (USDOC, NMFS, 2007b), a deep-diving species, the faster-diving marine mammal species with less surface recovery time would be expected to have even less risk of vessel strikes. Although manatees have been killed by vessel strikes (e.g., Schiro et al., 1998), they are rare in the deepwater GOM, and consequently, the proposed activity should pose little, if any, risk to them. The continued presence of sperm whales in close proximity to some of the deepwater structures in the GOM tends to lessen the concern of permanent displacement by disturbances caused by activity in support of offshore drilling or production.

The dominant source of noise from vessels is from the propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from the proposed action will produce low

levels of noise, generally in the 150-170 dB re 1 μPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. As a result, NMFS's 2007 ESA Biological Opinion concluded that the effects to sperm whales from vessel noise are discountable (USDOC, NMFS, 2007b). The BOEMRE has proposed adherence with the guidance provided under NTL 2007-G04, "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting." Compliance with the regulations as clarified in this NTL should negate or lessen the chance of significant impacts to marine mammals.

The noise and the shadow from helicopter overflights, take-offs, and landings can cause a startle response and can interrupt whales and dolphins while resting, feeding, breeding, or migrating (Richardson et al., 1995). The Federal Aviation Administration's Advisory Circular 91-36D (September 17, 2004) encourages pilots to maintain higher than minimum altitudes over noise-sensitive areas. Guidelines and regulations put in place by NOAA Fisheries under the authority of the Marine Mammal Protection Act include provisions specifying that helicopter pilots maintain an altitude of 1,000 ft (305 m) within 300 ft (91 m) of marine mammals. Helicopter occurrences would be temporary and pass within seconds. Marine mammals are not expected to be adversely affected by routine helicopter traffic operating at prescribed altitudes.

Atmospheric noise inputs, however, are negligible relative to other sources of noise that are propagated in water (e.g., vessel traffic and platform and drill rig operations). Noise from service-vessel traffic may elicit a startle and/or avoidance reaction from whales and dolphins or mask their sound reception. There is the possibility of short-term disruption of movement patterns and behavior, but such disruptions are unlikely to affect survival or productivity. The behavioral disruptions potentially caused by noise and the presence of service-vessel traffic will have negligible affects on cetacean populations in the northern Gulf of Mexico.

Drilling activities would produce sounds transmitted into the water at intensities and frequencies that could be heard by cetaceans. Noise from drilling could be intermittent, sudden, and at times could be high intensity as operations take place. Sound from a fixed, ongoing source like an operating drillship is continuous. However, the distinction between transient and continuous sounds is not absolute on a drillship as generators and pumps operate essentially continuously, but there are occasional transient bangs and clangs from various impacts during operations (Richardson et al., 1995). Drilling from semisubmersible vessels estimated frequencies are broadband from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1μPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB (Greene, 1986). The potential effects that water-transmitted noise have on marine mammals include disturbance (subtle changes in behavior, interruption of previous activities, or short- or long-term displacement), masking of sounds (calls from conspecifics, reverberations from own calls, and other natural sounds such as surf or predators), physiological stress, and hearing impairment. Individual marine mammals exposed to recurring disturbance could be negatively affected. Malme et al. (1986) observed the behavior of feeding gray whales in the Bering Sea during four experimental playbacks of drilling sounds (50-315 Hz; 21-minute overall duration and 10% duty cycle; source levels 156-162 dB re: 1 μPa-m). In two cases for received levels 100-110 dB re: 1 μPa, there was no observed behavioral reaction. Avoidance behavior was observed in two cases where received levels were 110-120 dB re: 1 μPa. These source levels are all below NMFS's current 160-dB level B harassment threshold under the MMPA.

The source levels from drilling are relatively low (154 dB and below, as cited by Greene, 1986, in Richardson et al., 1995), which is below the level B (behavioral) harassment threshold of 160 dB (set by NMFS). According to Southall et al. (2007), for behavioral responses to nonpulses (such as drill noise), data indicate considerable variability in received levels associated with behavioral responses. Contextual variables (such as novelty of the sound to the marine mammal and operation features of the sound source) appear to have been at least as important as exposure level in predicting response type and magnitude. While there is some data from the Arctic on baleen whales, there is little data on the behavioral responses of marine mammals in the Gulf of Mexico from the sound of drilling. Southall et al. (2007) summarized the existing research, stating that the probability of avoidance and other behavioral affects increases when received levels increase from 120 to 160 dB. Marine mammals may exhibit some avoidance behaviors, but their behavioral or physiological responses to noise associated with the proposed project, however, are unlikely to have population-level impacts to marine mammals in the northern Gulf of Mexico.

The BOEMRE published a Programmatic EA on decommissioning operations (USDOI, MMS, 2005) that, in part, addresses the potential impacts of explosive and nonexplosive-severance activities on OCS resources, particularly upon marine mammals and sea turtles. Pursuant to 30 CFR 250 Subpart Q, operators must obtain a permit from BOEMRE before beginning any platform removal or well-severance activities. During the review of the permit applications, terms and conditions of the August 2006 NMFS Biological Opinion/Incidental Take Statement are implemented for the protection of marine protected species and to reduce possible impacts from any potential activities resulting from the proposed lease sale. The NMFS has issued regulations (50 CFR 216) under the MMPA for "Taking Marine Mammals Incidental to the Explosive Removal of Offshore Structures in the Gulf of Mexico."

In 30 CFR 250 Subpart B, BOEMRE requires operators of Federal oil and gas leases to meet the requirements of ESA and MMPA. The regulations outline the environmental, monitoring, and mitigation information that operators must submit with plans for exploration, development, and production. This regulation requires OCS activities to be conducted in a manner that is consistent with the provisions of ESA and MMPA.

Seismic operations have the potential to harm marine mammals in close proximity to firing airgun arrays, especially if they are directly beneath airguns when surveying begins. The proposed Protected Species Stipulation and several suggested mitigation measures, including onboard observers and airgun shut-downs for whales in the exclusion zone, included in NTL 2007-G02, "Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program," minimize the potential of harm from seismic operations to marine mammals. The proposed adherence with the guidance provided under NTL 2007-G02 should negate or lessen the chance of significant impacts to marine mammals.

Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where cetaceans could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect marine mammals. Industry has made good progress in debris management on vessels and offshore structures in the last several years. The proposed adherence with the guidance provided under NTL 2007-G03, "Marine Trash and Debris Awareness and Elimination," appreciably reduces the likelihood of marine mammals encountering marine debris from the proposed activity.

Summary and Conclusion

In this Supplemental EIS, BOEMRE has reexamined the analysis for marine mammals presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and has considered the recent reports cited above and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM on the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

Mysticetes, as low-frequency hearing specialists, are the species groups most likely to be susceptible to impacts from the low-frequency nonpulse sound (intermittent or continuous), given that their hearing ranges overlap most closely with the noise frequencies produced from drilling (Southall et al., 2007). However, most mysticete species that may occur in the GOM (i.e., North Atlantic right, blue, fin, sei, humpback, and minke whales) are considered either "extralimital," "rare," or "uncommon"; however, a small population of Bryde's whales is common in the eastern GOM (Würsig et al., 2000; Waring et al., 2009). Because of the geographic scope of the proposed action, the presence of these species within the action area is unlikely.

The remaining marine mammal species in the GOM (e.g., sperm whales, dwarf or pygmy sperm whales, and dolphins) are considered mid-frequency hearing specialists with hearing ranges that slightly overlap with sound frequencies produced from drilling noise (Southall et al., 2007). It is expected that there will be some overlap in the frequencies of the drill source and the hearing thresholds of the marine

mammals present in the GOM. Greene (1986) estimated the broadband frequencies of semisubmersible drill vessels to be from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1µPa at 1 m. Tones of 60 Hz had source levels of 149 dB, 181 Hz was 137 dB, and 301 Hz was 136 dB. Wartzok and Ketten (1999) stated that bottlenose dolphins have hearing thresholds ranging from less than 5 kHz to over 100 kHz. Ridgway and Carder (2001) found, through auditory brainstem analysis, that pygmy sperm whales have thresholds from 90 to 150 kHz. Gordon et al. (1996) found that a stranded sperm whale had lower hearing limits at around 100 Hz, while Ridgway and Carder (2001) found that a sperm whale calf had best hearing sensitivity between 5 and 20 kHz. Since there is some overlap in the sound levels produced and hearing thresholds of marine mammals, there is the potential for the drilling noise produced to cause auditory and nonauditory effects, permanent threshold shift, temporary threshold shift, behavioral changes, or masking, but it is expected to be limited. However, these levels are under the NMFS 160-dB level B harassment under the MMPA.

The NMFS sets the 180-dB, root-mean-squared isopleth where on-set of auditory injury or mortality (level A harassment) to cetaceans may occur. Southall et al. (2007) suggest this level should rather be at 230 dB root-mean-squared for a nonpulsed sound, such as drilling noise. Richardson et al. (1995) cited Greene (1986) and stated that drilling from semisubmersible vessels have estimated broadband frequencies from 80 to 4,000 Hz, with an estimated source level of 154 dB re 1µPa at 1 m. Tones of 60 Hz have source levels of 149 dB, while 181 Hz have source levels of 137 dB and 301 Hz have source levels of 136 dB. These source levels all fall below the 180-dB level A harassment isopleths.

Because of the mitigations described in the above analysis, routine activities (e.g., operational discharges, noise, vessel traffic, and marine debris) related to the proposed CPA lease sale are not expected to have long-term adverse effects on the size and productivity of any marine mammal species or population in the northern GOM. Lethal effects are most likely to be from chance collisions with OCS service vessels or ingestion of any accidentally released plastic materials. Most routine OCS activities are expected to have sublethal effects. In conclusion, the scope, timing, and transitory nature of the proposed action and the mitigation and monitoring requirements in place, the noise related to the CPA proposed action is not expected to result in permanent threshold shift, temporary threshold shift, behavioral change, masking, or nonauditory effects to marine mammals in the GOM that would rise to the level of significance.

4.1.1.11.3. Impacts of Accidental Events

A detailed impact analysis of marine mammals for the CPA proposed action can be found in Chapter 4.4.5 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.6.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Potential effects on marine mammal species may occur from accidental activities associated with the CPA proposed action and may be direct or indirect. The major potential impact-producing factors affecting marine mammals in the GOM as a result of accidental OCS activities include accidental blowouts, oil spills, and spill-response activities. Characteristics of impacts (i.e., acute vs. chronic impacts) depend on the magnitude, frequency, location, and date of accidents; characteristics of spilled oil; spill-response capabilities and timing; and various meteorological and hydrological factors. Chronic or acute exposure may result in harassment, harm, or mortality to marine mammals. Studies have shown varying results. Marine mammals made no apparent attempt to avoid spilled oil in some cases (Smultea and Würsig, 1995); however, marine mammals have been observed apparently detecting and avoiding slicks in other reports (Geraci and St. Aubin, 1990). Exposure to hydrocarbons persisting in the sea following the dispersal of a large oil slick is likely to result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) to marine mammals.

Activities considered under this activity could affect protected sirenians (manatees) as well. Manatees are generally extralimital in western Louisiana and are rare in waters of the CPA, but they have occurred in the warm waters of Lake Pontchartrain (Louisiana Dept. of Wildlife and Fisheries, 2005).

Protected marine mammals could be impacted by marine debris, contaminant spills and spill-response activities, vessel traffic, noise, seismic surveys, explosive structure removals, commercial fishing, capture activities, and pathogens.

The oil from an oil spill can adversely affect cetaceans by causing soft tissue irritation, fouling of baleen plates, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats. The long-term impacts to marine mammal populations are poorly understood but could include decreased survival and lowered reproductive success. The range of toxicity and degree of sensitivity to oil hydrocarbons and the effects of cleanup activities on cetaceans are unknown. One assumption concerning the use of dispersants is that chemical dispersion of oil will considerably reduce the impacts to seabirds and aquatic mammals, primarily by reducing their exposure to petroleum hydrocarbons (French-McCay 2004; NRC, 2005). Chemical dispersant application during an oil spill may lower the amount of oil to which a bird or aquatic mammal is exposed, while increasing the potential loss of the insulative properties of feathers or fur through the reduction of surface tension at the feather/fur-water interface (NRC, 2005).

Impacts from the dispersants are unknown but may have similar irritants to tissues and sensitive membranes as they are known to have had on seabirds and marine mammals (NRC, 2005). There have been no experimental studies and only a handful of observations suggesting that oil has harmed any manatees (St. Aubin and Lounsbury, 1990). Types of impacts to manatees and dugongs from contact with oil include (1) asphyxiation due to inhalation of hydrocarbons, (2) acute poisoning due to contact with fresh oil, (3) lowering of tolerance to other stress due to the incorporation of sublethal amounts of petroleum components into body tissues, (4) nutritional stress through damage to food sources, and (5) inflammation or infection and difficulty eating due to oil sticking to the sensory hairs around their mouths (Preen, 1989, in Sadiq and McCain, 1993; Australian Maritime Safety Authority, 2003). For a population whose environment is already under great pressure, even a localized incident could be significant (St. Aubin and Lounsbury, 1990). Spilled oil might affect the quality or availability of aquatic vegetation, including seagrasses, upon which manatees feed.

The ESA (16 U.S.C. 1631 et seq.), as amended (43 U.S.C. 1331 et seq.), establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. The ESA is administered by FWS and NMFS. Section 7 of the ESA governs interagency cooperation and consultation. Under Section 7, BOEMRE consults with FWS and NMFS to ensure that OCS activities under BOEMRE jurisdiction do not jeopardize the continued existence of threatened or endangered species and/or result in adverse modification or destruction of their critical habitat.

The formal consultation with NMFS was concluded with receipt of the Biological Opinion dated June 29, 2007, and received by BOEMRE on July 3, 2007 (USDOC, NMFS, 2007b). The Biological Opinion concludes that the proposed lease sale and associated activities in the GOM during the current 5-Year Program, which includes the CPA proposed action, are not likely to jeopardize the continued existence of threatened and endangered species under NMFS jurisdiction or destroy or adversely modify designated critical habitat.

Section 7(b)(4)(c) of the ESA specifies that, in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under Section 101(a)(5) of the Marine Mammal Protection Act (MMPA). Since no incidental take of listed marine mammals is expected or has been authorized under Section 101(a)(5)(A) of the MMPA and/or its 1994 amendments (see ESA Section 7(b)(4)(C)), no statement on incidental take of endangered whales is provided and no take is authorized. Nevertheless, BOEMRE must immediately notify (within 24 hours, if communication is possible) NMFS's Office of Protected Resources should a take of a listed marine mammal occur.

On December 26, 2002, this Agency petitioned NMFS for rulemaking under the MMPA for the taking, by harassment, of sperm whales incidental to the oil and gas industry's seismic surveys to discover oil and gas deposits offshore in the GOM. The NMFS published a notice of receipt of the application on March 3, 2003 (68 FR 9991). This Agency then submitted a revised petition on September 26, 2004, to include the incidental take of other species of marine mammals. On July 30, 2004, this Agency completed its final programmatic EA on the action. On November 18, 2004, NMFS published a Notice of Intent to Prepare an EIS, a notice of public meetings, and a request for scoping comments. The BOEMRE and NMFS are working together as co-lead agencies on the EIS and, due to lengthy delays in the MMPA process, BOEMRE is currently updating and revising its previously

submitted petition for MMPA rulemaking. Following issuance of such regulations under the MMPA, NMFS will amend their opinion to include any authorized incidental take of sperm whales, as may be appropriate at that time.

The NMFS believes that a small number of listed species would experience adverse effects as the result of exposure to a large oil spill or ingestion of accidentally spilled oil over the lifetime of the proposed action. As per the 2007 Biological Opinion, NMFS stated that spilled oil resulting from the proposed sales (Lease Sale 216/222 included) could cause up to 11 nonlethal takes of sperm whales over the 40-year lifetime of the proposed lease sale. However, NMFS is not including an incidental take statement for the incidental take of listed species due to oil exposure. Incidental take, as defined at 50 CFR 402.02, refers only to takings that result from an otherwise lawful activity. The Clean Water Act (33 U.S.C. 1251 et seq.) as amended by the Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.) prohibits discharges of harmful quantities of oil, as defined at 40 CFR 110.3, into waters of the United States. Therefore, even though the Biological Opinion considered the effects on listed species by oil spills that may result from the CPA proposed action, those takings that would result from an unlawful activity (i.e., oil spills) are not specified in this Incidental Take Statement and have no protective coverage under Section 7(o)(2) of the ESA.

The DWH event and resulting oil spill in Mississippi Canyon Block 252 and related spill-response activities may impact marine mammals that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected marine mammal environment. For the latest available information on oiled or affected marine mammals documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c). More detail on the potential range of effects to marine mammals from contact with spilled oil can be found in Geraci and St. Aubin (1990) and on the NMFS Office of Protected Resources website (http://www.nmfs.noaa.gov/pr/health/oilspill/mammals.htm). The NRDA-related efforts are ongoing and the results will be incorporated into future environmental analyses.

A similar yet not comparable blowout of the *Ixtoc I* offshore drilling rig in the Bay of Campeche, Mexico on June 3, 1979, resulted in the release of 500 thousand metric tons (140 million gallons) and transport of this oil into the Gulf of Mexico (ERCO, 1982). The effect on marine mammals was undetermined.

Summary and Conclusion

The BOEMRE has reexamined the analysis for marine mammals presented in the Multisale EIS and the Supplemental EIS, and has considered the recent reports cited above and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

In the event of a catastrophic spill similar to the DWH event, any substantive impact to marine mammals is very unlikely because the potential impacts from a catastrophic spill would be similar to the aforementioned routine and accidental issues. However, despite the recent DWH event, historical trends in the GOM indicate that catastrophic spill events are not likely to occur as a result of drilling and temporary abandonment.

4.1.1.11.4. Cumulative Impacts

A detailed impact analysis of marine mammals for the CPA proposed action can be found in Chapter 4.5.5 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.6.4 of the 2009-2012 Supplemental EIS.

The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

The major potential impact-producing factors affecting protected marine mammals in the GOM as a result of cumulative OCS activities include marine debris, contaminant spills and spill-response activities, vessel traffic, noise, seismic surveys, explosive structure removals, commercial fishing, capture activities, and pathogens. Activities considered under the cumulative scenario could affect protected cetaceans and sirenians (manatees). Manatees, known to have occurred in the warm waters of Lake Pontchartrain in the weeks before Hurricane Katrina (Louisiana Dept. of Wildlife and Fisheries, 2005), are generally extralimital in western Louisiana.

The proposed action may cumulatively affect protected cetaceans when viewed in light of the DWH event and associated cleanup activities. Marine mammals could be impacted by oil and gas leasing, exploration, development, and production activities including the degradation of water quality resulting from operational discharges; vessel traffic; noise generated by platforms, drillships, helicopters and vessels; seismic surveys; explosive structure removals; oil spills; oil-spill-response activities; loss of debris from service vessels and OCS structures; commercial fishing; capture and removal; and pathogens. The cumulative impact on marine mammals is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) that may stress and/or weaken individuals of a local group or population and predispose them to infection from natural or anthropogenic sources (Harvey and Dahlheim, 1994).

Few deaths are expected from chance vessel collisions, ingestion of plastic material, commercial fishing, and pathogens. Disturbance (noise from vessel traffic and drilling operations, etc.) and/or exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal (Harvey and Dahlheim, 1994). The net result of any disturbance will depend upon the size and percentage of the population likely to be affected, the ecological importance of the disturbed area, the environmental and biological parameters that influence an animal's sensitivity to disturbance and stress, or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980).

The effects of the proposed action, when viewed in light of the effects associated with other relevant activities, may impact marine mammals in the GOM. However, the operator is required to follow all existing lease stipulations and regulations as clarified by NTL's. Because of the operator's reaffirmed compliance with NTL 2007-G04 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") and NTL 2007-G03 ("Marine Trash and Debris Awareness and Elimination"), as well as the limited scope, timing, and geographic location of the proposed action, effects from the proposed drilling activities on marine mammals will be negligible. Therefore, no significant cumulative impacts to marine mammals would be expected as a result of the proposed exploration activities when added to the impacts of past, present, or reasonably foreseeable oil and gas development in the area, as well as other activities in the area.

Natural phenomenon, such as tropical storms and hurricanes, are impossible to predict, but will occur in the GOM. Generally, the offshore species and the offshore habitat are not expected to be severely affected in the long term. Species that occupy more nearshore habitats, however, may suffer more long-term impacts. The effects of recent GOM hurricanes are difficult to assess, but major impacts to GOM marine mammal populations have not been reported.

Effects of the incremental contribution of the CPA proposed action, combined with non-OCS activities, may be deleterious to marine mammals occurring in the GOM. Biological significance of any mortality would depend, in part, on the size and reproductive rates of the affected stocks, as well as the number, age, and size of animals affected. However, potential impacts from the CPA proposed action activities are not expected to result in mortality.

Summary and Conclusion

The BOEMRE has reexamined the analysis for marine mammals presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and has considered the recent reports cited above and other new

information. The GOM tropical storm activity in recent years is not expected to have altered the cumulative effects baseline for marine mammals. Therefore, the incremental effect of the CPA proposed action upon these resources is unchanged, and the description of the environmental effects of the proposed action upon these resources described in the Multisale EIS and the 2009-2012 Supplemental EIS remains unchanged. Because of the regulations, geographic location of the proposed action, and the low probabilities of large accidental events, the cumulative effects to marine mammal populations are expected to be minor.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

4.1.1.12. Sea Turtles

The BOEMRE has reexamined the analysis for the five sea turtles species that inhabit the Gulf of Mexico in the Multisale EIS and the 2009-2012 Supplemental EIS based on the additional information presented below and in consideration of the DWH event. While information from the 5-year status reviews for federally listed sea turtles in the Gulf of Mexico was incorporated, there was no substantial new information that would alter the impact conclusion for sea turtles presented in the Multisale EIS and the 2009-2012 Supplemental EIS. In most foreseeable cases, exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick would result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) to sea turtles.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information and the addition of the 181 South Area is presented in the following sections and the 2009-2012 Supplemental EIS. A brief summary of potential impacts follows. The routine activities of the proposed action are unlikely to have significant adverse effects on the size and recovery of any sea turtle species or population in the Gulf of Mexico. Accidental events associated with the proposed action have the potential to impact small to large numbers of sea turtles. Populations of sea turtles in the northern Gulf of Mexico would be exposed to residuals of oils spilled as a result of the proposed action during their lifetimes. While chronic or acute exposure from accidental events may result in the harassment, harm, or mortality to sea turtles, in most foreseeable cases, exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick would result in sublethal impacts. However, the incremental contribution of a CPA proposed action, including the 181 South Area, to the numerous cumulative impacts to sea turtles are not expected to be significant, especially due to mitigations currently in place.

4.1.1.12.1. Description of the Affected Environment

A detailed description of sea turtles can be found in Chapter 3.2.4 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.7 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Five sea turtles are known to inhabit the waters of the GOM (Pritchard, 1997): the leatherback (endangered, listed June 2, 1970); green turtle (breeding colony populations in Florida and on the Pacific Coast of Mexico are listed as endangered; all others are listed as threatened, listed July 28, 1978); hawksbill (endangered, listed June 2, 1970); Kemp's ridley (endangered, listed December 2, 1970); and loggerhead (threatened, listed July 28, 1978). These five species are all highly migratory (**Table 4-3**). Individual animals will make migrations into nearshore waters as well as other areas of the North Atlantic

Ocean, Gulf of Mexico, and the Caribbean Sea. All five species of sea turtles found in the Gulf of Mexico have been federally listed as endangered or threatened since the 1970's. There is currently no critical habitat designated in the Gulf of Mexico. On February 17, 2010, NMFS and FWS were jointly petitioned to designate critical habitat for Kemp's ridley sea turtles for nesting beaches along the Texas coast and for marine habitats in the Gulf of Mexico and Atlantic Ocean. The NMFS is currently reviewing the petition.

The DWH event and related spill-response activities may impact sea turtles that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected sea turtle environment. For the latest available information on oiled or affected sea turtles documented in the area, event response (including nest relocation), and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c). More detail on the potential range of effects to sea turtles from contact with spilled oil can be found on the NMFS Office of Protected Resources website (http://www.nmfs.noaa.gov/pr/health/oilspill/turtles.htm).

A similar yet not comparable blowout of the *Ixtoc I* offshore drilling rig in the Bay of Campeche, Mexico, on June 3, 1979, resulted in the release of 500,000 metric tons (140 million gallons) and the transport of this oil into the Gulf of Mexico (ERCO, 1982). Of the three sea turtles found dead in the U.S., all had petroleum hydrocarbons in the tissues examined and there was selective elimination of portions of this oil, indicating chronic exposure (Hall et al., 1983).

In August 2007, FWS and NMFS published 5-year status reviews for federally listed sea turtles in the Gulf of Mexico (USDOC, NMFS and USDOI, FWS, 2007a-e). A 5-year review is an ESA-mandated process that is conducted to ensure the listing classification of a species as either threatened or endangered is still accurate. Both agencies share jurisdiction for federally listed sea turtles and jointly conducted the reviews. After reviewing all of the best scientific and commercially available information and data, the agencies' biologists recommended that the current listing classification for the five sea turtle species remain unchanged.

Natural phenomenon, such as tropical storms and hurricanes, are impossible to predict, but they will occur in the GOM. Generally, the offshore species and the offshore habitat are not expected to be severely affected in the long term. However, species that occupy more nearshore habitats and those that use nearshore habitats for nesting may suffer more long-term impacts. Several major hurricanes have hit the Gulf Coast in the last several years. Storm impacts, including loss of nesting habitat, increased marine debris, and spilled pollutants, can be detrimental to sea turtles. Impacts from the storms to nesting activity can be hard to assess. Hurricane Katrina in 2005 decimated the northern Gulf Coast, including the Chandeleur Islands off of Louisiana/Mississippi. This barrier island chain was a significant loggerhead nesting site (Lohoefener et al., 1990). Very little area that would be suitable for nesting remains above sea level. Subsequent storms have delayed any rebuilding of the Chandeleur Islands. Hurricane Gustav in 2008 also occurred in areas used by sea turtles for nesting. Both the washing away of sand beaches and the proliferation of debris on nesting beaches can post major barriers to successful nesting. The late August/September timeframe of most of the recent Gulf of Mexico storms was toward the end of the sea turtle nesting season (generally April/May to October). Many nests had successfully hatched prior to storm damage (Florida Fish and Wildlife Conservation Commission, 2008).

In response to a request by the Gulf of Mexico Fishery Management Council, NMFS issued an emergency closure for the bottom longline fishery in the eastern Gulf from May 18 through October 28, 2009 (*Federal Register*, 2009c). This action was promulgated by recent observer data analysis that showed the number of sea turtle takes authorized in a 2005 Biological Opinion had been substantially exceeded. The affected fishery operates primarily off the west Florida shelf, which is an important sea turtle foraging habitat. A decline in the number of reproducing female loggerheads has been suggested as one of the reasons for recent declines in the annual loggerhead sea turtle nest counts in peninsular Florida. The bottom longline fishery takes sea turtles, including adult females, incidentally as bycatch. Further restrictions and/or mitigations may be required after the expiration of this closure. Although the area of greatest impact from this commercial fishing activity is not in the CPA, such impact to the loggerhead sea turtle population must be considered with cumulative impacts. Concern over declining numbers of loggerhead sea turtles is reflected in NMFS's second revision of the Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*), which replaced the previous 1991 report (USDOC, NMFS and USDOI, FWS, 2008).

Leatherback Sea Turtle

The leatherback is the most abundant sea turtle in waters over the northern Gulf of Mexico continental slope (Mullin and Hoggard, 2000). The leatherback sea turtle is listed as endangered. Leatherbacks appear to spatially use both continental shelf and slope habitats in the Gulf of Mexico (Fritts et al., 1983; Collard, 1990; Davis and Fargion, 1996). Surveys suggest that the region from Mississippi Canyon to De Soto Canyon, especially near the shelf edge, appears to be an important habitat for leatherbacks (Mullin and Hoggard, 2000). Leatherbacks have been frequently sighted in the Gulf of Mexico during both summer and winter (Mullin and Hoggard, 2000).

In Florida, an increase in leatherback nesting numbers from 98 nests in 1988 to 800-900 nests per season in the early 2000's has been recorded. There has been a substantial increase in leatherback nesting in Florida since 1989 (USDOC, NMFS and USDOI, FWS, 2007a). Florida received a near record number of leatherback nests on beaches in 2010 (Florida Fish and Wildlife Conservation Commission, 2010a). Although nesting is very rare on Gulf of Mexico beaches, leatherbacks occur in Gulf of Mexico waters. Satellite telemetry and tag returns have shown that some of the leatherbacks present in the Gulf of Mexico were tagged at nesting beaches in Costa Rica and Panama (USDOC, NMFS and USDOI, FWS, 2007a).

Critical habitat for the leatherback includes the waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands. There is no critical habitat designation for the leatherback sea turtle in the GOM. Ongoing threats to leatherbacks include ingestion of marine debris, poaching of eggs and animals, and entanglement in longline fishing gear.

Green Sea Turtle

All green sea turtle populations are listed as threatened except for the breeding populations of Florida and the Pacific Coast of Mexico, which are endangered. Green sea turtles are found throughout the Gulf of Mexico and are known to nest on Gulf of Mexico beaches, but in very small numbers. Reports of green turtles nesting along the Gulf Coast are infrequent.

The east coast of Florida is one of the most important nesting areas for green turtles. Between 1989 and 2010, the annual number of green sea turtle nests ranged from 267 to 9,091. Green turtle nests have increased by a factor of 10 over the last 22 years (Florida Fish and Wildlife Conservation Commission, 2010a).

The principal cause of past declines and extirpations of green turtle assemblages has been the over-exploitation of green turtles for eggs and meat. Significant threats on green turtle nesting beaches in the region include beach armoring, erosion control, artificial lighting, and disturbance. Armoring of beaches (e.g., seawalls, revetments, rip-rap, sandbags, and sand fences) in Florida, which is meant to protect developed property, is increasing and has been shown to discourage nesting, even when armoring structures do not completely block access to nesting habitat (Mosier, 1998).

Hawksbill Sea Turtle

Hawksbill sea turtles were once abundant in tropical and subtropical regions. Pelagic-size individuals and small juveniles are not uncommon and are believed to be animals dispersing from nesting beaches in the Yucatán Peninsula of Mexico and farther south in the Caribbean (Amos, 1989). The hawksbill turtle is listed as endangered and is considered critically endangered by the International Union for the Conservation of Nature based on global population declines of over 80 percent during the last three generations (105 years) (Meylan and Donnelly, 1999). The Atlantic Coast of Florida is the only area in the U.S. where hawksbills nest on a regular basis.

Hawksbills are threatened by all the factors that threaten other marine turtles, including exploitation for meat, eggs, and the curio trade; loss or degradation of nesting and foraging habitats; increased human presence; nest depredation; oil pollution; incidental capture in fishing gear; ingestion of and entanglement in marine debris; and boat collisions (Lutcavage et al., 1997; Meylan and Ehrenfeld, 2000). The primary cause of hawksbill decline has been attributed to centuries of exploitation for tortoiseshell, the beautifully patterned scales that cover the turtle's shell (Parsons, 1972). Another manmade factor that affects hawksbills in foraging areas and on nesting beaches is global climate change (USDOC, NMFS and USDOI, FWS, 2007c).

Kemp's Ridley Sea Turtle

Ogren (1989) suggests that the Gulf Coast, from Port Aransas, Texas, through Cedar Key, Florida, represents the primary habitat for subadult ridleys in the northern Gulf of Mexico. Internationally, the Kemp's ridley is considered the most endangered sea turtle. There is no designated critical habitat for the Kemp's ridley sea turtle. There is no designated critical habitat; however, on February 17, 2010, NMFS and FWS were jointly petitioned to designate critical habitat for Kemp's ridley sea turtles for nesting beaches along the Texas coast and for marine habitats in the Gulf of Mexico and Atlantic Ocean. The NMFS is currently reviewing the petition.

The species occurs mainly in coastal areas of the Gulf of Mexico and the northwestern Atlantic Ocean. Kemp's ridleys nest in daytime aggregations known as arribadas, primarily at Rancho Nuevo, a stretch of beach in Mexico, Tamaulipas State. A 2007 arribada at Rancho Nuevo included over 4,000 turtles over a 3-day period (USDOC, NMFS and USDOI, FWS, 2007d). Kemp's ridley sea turtle nest numbers reported along the 47-mi (76-km) stretch of Alabama coastline were 1 nest in 2006, 2007, and 2008. Louisiana and Mississippi have few, if any, nests.

Of the seven extant species of sea turtles in the world, the Kemp's ridley has declined to the lowest population level. Many threats to the future of the species remain, including interactions with fishery gear, marine pollution, foraging habitat destruction, illegal poaching of nests, and the potential threats to nesting beaches from such sources as global climate change, development, and tourism pressures (USDOC, NOAA, 2011a).

Loggerhead Sea Turtle

Loggerhead nesting along the Gulf Coast occurs primarily along the Florida Panhandle, although some nesting has been reported from Texas through Alabama (USDOC, NMFS and USDOI, FWS, 1991). Loggerhead turtles have been primarily sighted in waters over the continental shelf, although many surface sightings of this species have also been made over the outer slope beyond the 1,000-m (3,281-ft) isobath. The loggerhead sea turtle is listed as threatened.

Ongoing threats to the western Atlantic loggerhead populations include incidental takes from dredging, commercial trawling, longline fisheries, and gillnet fisheries; loss or degradation of nesting habitat from coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; nest predation by native and nonnative predators; degradation of foraging habitat; marine pollution and debris; watercraft strikes; and disease (USDOC, NOAA, 2011a).

In the past decade, a 39.5 percent decline in the annual number of nests has been reported (USDOC, NMFS and USDOI, FWS, 2007e). The Florida Panhandle Nesting Subpopulation showed a decline of 6.6 percent annually from 1995 to 2005. Loggerhead sea turtle nest numbers in 2010 were above the average of the preceding 10-year period (Florida Fish and Wildlife Conservation Commission, 2010b). Along the 47-mi (76-km) stretch of Alabama coastline, 62 loggerhead nests were reported in 2003, 53 in 2004, 37 in 2005, 45 in 2006 and 1 Kemp's ridley nest, 54 in 2007 and 1 Kemp's ridley nest, and 78 in 2008 and 1 Kemp's ridley nest. Louisiana and Mississippi have few if any nests.

Recent Consultation

As mandated by the ESA, BOEMRE consulted with NMFS and FWS on possible and potential impacts from a CPA or WPA proposed action on endangered/threatened species and designated critical habitat under their jurisdiction. A biological assessment was prepared for each consultation. The action area analyzed in the biological assessments included the lease sale areas addressed in this Supplemental EIS.

The formal ESA consultation with NMFS was concluded with receipt of the Biological Opinion on July 3, 2007 (USDOC, NMFS, 2007b). The Biological Opinion concludes that the proposed lease sales and associated activities in the Gulf of Mexico in the 5-Year Program are not likely to jeopardize the continued existence of threatened and endangered species under NMFS jurisdiction or destroy or adversely modify designated critical habitat. The following information was present in the Biological Opinion, but not in the Multisale EIS. The informal ESA consultation with FWS was concluded with a letter dated September 14, 2007. The FWS concurred with this Agency's determination that proposed

actions of the 5-Year Program were not likely to adversely affect the threatened/endangered species or designated critical habitat under FWS jurisdiction.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

4.1.1.12.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of sea turtles for the CPA proposed action can be found in Chapter 4.2.2.1.6 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.7.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Routine activities resulting from the CPA proposed action have the potential to harm sea turtles. The major impact-producing factors resulting from the routine activities associated with the CPA proposed action that may affect loggerhead, Kemp’s ridley, hawksbill, green, and leatherback turtles include the degradation of water quality resulting from operational discharges; noise generated by helicopter and vessel traffic, platforms, and drillships, and seismic exploration; vessel collisions; and marine debris generated by service vessels and OCS facilities.

Contaminants in waste discharges and drilling muds might indirectly affect sea turtles through food-chain biomagnification, but there is uncertainty concerning the possible effects. Most operational discharges are diluted and dispersed when released in offshore areas and are considered to have sublethal effects (NRC, 1983; API, 1989; Kennicutt, 1995; Kennicutt et al., 1996). Any potential impacts from drilling fluids would be indirect, either as a result of impacts to prey species or possibly through ingestion via the food chain (Neff et al., 1989). Impacts from water degradation are expected to be negligible due to the wide-ranging habits of sea turtle species in the GOM.

The first impact-producing factor associated with the CPA proposed action that could affect ESA-listed sea turtles is impacts from vessel noise and vessel collisions. The dominant source of noise from vessels is propeller operation, and the intensity of this noise is largely related to ship size and speed. Vessel noise from the proposed action would produce low levels of noise, generally in the 150- to 170-dB re 1 µPa-m at frequencies below 1,000 Hz. Vessel noise is transitory and generally does not propagate at great distances from the vessel. Also, available information indicates that sea turtles do not greatly utilize environmental sound. As a result, NMFS’s 2007 Biological Opinion concluded that effects to sea turtles from vessel noise are discountable (USDOC, NMFS, 2007b).

Drilling activities would produce sounds transmitted into the water that could be intermittent, sudden, and at times could be high intensity as operations take place. However, sea turtles are not expected to be impacted by this disturbance because NMFS, in their 2007 Biological Opinion, determined that “drilling is not expected to produce amplitudes sufficient to cause hearing or behavioral effects to sea turtles or sperm whales; therefore, these effects are insignificant.”

Sea turtles spend at least 3-6 percent of their time at the surface for respiration, and perhaps as much as 26 percent of time at the surface for basking, feeding, orientation, and mating (Lutcavage et al., 1997). Data show that collisions with all types of commercial and recreational vessels are a cause of sea turtle mortality in the GOM (Lutcavage et al., 1997). Stranding data for the U.S. Gulf and Atlantic Coasts,

Puerto Rico, and the U.S. Virgin Islands show that between 1986 and 1993 about 9 percent of living and dead stranded sea turtles had boat strike injuries (Lutcavage et al., 1997). Vessel-related injuries were noted in 13 percent of stranded turtles examined from the Gulf of Mexico and the Atlantic during 1993 (Teas, 1994), but this figure includes those that may have been struck by boats post-mortem. Large numbers of loggerheads and 5-50 Kemp's ridley turtles are estimated to be killed by vessel traffic per year in the U.S. (NRC, 1990; Lutcavage et al., 1997).

There have been no documented sea turtle collisions with drilling and service vessels in the GOM; however, collisions with small or submerged sea turtles may go undetected. Based on sea turtle density estimates in the GOM, the encounter rates between sea turtles and vessels would be expected to be greater in water depths <200 m (656 ft) (USDOC, NMFS, 2007b). To further minimize the potential for vessel strikes, BOEMRE issued NTL 2007-G04, which clarifies 30 CFR § 250.282 and provides NMFS guidelines for monitoring procedures related to vessel strike avoidance measures for sea turtles and other protected species. With implementation of these measures and the avoidance of potential strikes from OCS vessels, NMFS's 2007 Biological Opinion concluded that the risk of collisions between oil/gas-related vessels (including those for G&G, drilling, production, decommissioning, and transport) and sea turtles is appreciably reduced, but strikes may still occur. The BOEMRE monitors for any takes that have occurred as a result of vessel strikes and also requires that any operator immediately report the striking of any animal (see 30 CFR § 250.282 and NTL 2007-G04).

To date, there have been no reported strikes of sea turtles by drilling vessels. Given the scope, timing, and transitory nature of the CPA proposed action and, with this established mitigation, effects to sea turtles from drilling vessel collisions is expected to be negligible.

Chronic sublethal effects (e.g., stress) resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas from noise disturbance, such as G&G activities, could cause declines in survival or fecundity and result in population declines; however, such declines are not expected. The NTL 2007-G02 provides guidance on mitigations that would minimize the potential impacts of seismic airguns to sea turtles. Observers are required to clear the exclusion area of sea turtles prior to ramp-up, and the subsequent gradual ramping up of the airguns may help minimize the impact of rapid onset of, and close proximity to, very loud noise.

The BOEMRE published a PEA on decommissioning operations (USDOI, MMS, 2005) that, in part, addresses the potential impacts of explosive and nonexplosive severance activities on OCS resources, particularly upon marine mammals and sea turtles. Pursuant to 30 CFR 250 Subpart Q, operators must obtain a permit from BOEMRE before beginning any platform removal or well-severance activities. During the review of the permit applications, terms and conditions of the August 2006 NMFS Biological Opinion/Incidental Take Statement are implemented for the protection of marine protected species and to reduce possible impacts from any potential activities resulting from the proposed lease sale.

In 30 CFR 250 Subpart B, BOEMRE requires operators of Federal oil and gas leases to meet the requirements of ESA. The regulation outlines the environmental, monitoring, and mitigation information that operators must submit with plans for exploration, development, and production. This regulation requires OCS activities to be conducted in a manner that is consistent with the provisions of ESA. Actual sea turtle impacts from explosive removals in recent years have been small. The updated pre- and post-detonation mitigations should ensure that injuries remain extremely rare.

Greatly improved handling of waste and trash by industry, along with the annual awareness training required by the marine debris mitigations, is decreasing the plastics in the ocean and minimizing the devastating effects on sea turtles. Many types of plastic materials end up as solid waste during drilling and production operations. Some of this material is accidentally lost overboard where sea turtles could consume it or become entangled in it. The incidental ingestion of marine debris and entanglement could adversely affect sea turtles. The BOEMRE proposes compliance with the guidelines provided in NTL 2007-G03, "Marine Trash and Debris Awareness and Elimination," which appreciably reduces the likelihood of sea turtles encountering marine debris from the proposed activity. The routine activities of the CPA proposed action are unlikely to have significant adverse effects on the size and recovery of any sea turtle species or population in the GOM.

Summary and Conclusion

In this Supplemental EIS, BOEMRE has reexamined the analysis for sea turtles presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and has considered the recent reports cited above and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. In the interim, BOEMRE will continue to comply with all Reasonable and Prudent Measures and the Terms and Conditions under these existing consultations, along with implementing the current BOEMRE-imposed mitigation, monitoring, and reporting requirements. Based on the most recent and best available information at the time, BOEMRE will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes.

Because of the mitigations described in the above analysis, routine activities (e.g., operational discharges, noise, vessel traffic, and marine debris) related to the proposed CPA lease sale are not expected to have long-term adverse effects on the size and productivity of any sea turtle species or populations in the northern GOM. Lethal effects are most likely to be from chance collisions with OCS service vessels or ingestion of accidentally released plastic materials. Most OCS activities are expected to have sublethal effects.

4.1.1.12.3. Impacts of Accidental Events

A detailed impact analysis of sea turtles for the CPA proposed action can be found in Chapter 4.4.6 of the 2007-2012 Multisale EIS and in Chapter 4.1.7.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Accidental activities resulting from the CPA proposed action have the potential to harm sea turtles. The major impact-producing factors resulting from the accidental activities associated with the CPA proposed action that may affect loggerhead, Kemp’s ridley, hawksbill, green, and leatherback turtles include accidental blowouts, oil spills, and spill-response activities. These have the potential to impact small to large numbers of sea turtles in the GOM, depending on the magnitude and frequency of accidents, the ability to respond to accidents, the location and date of accidents, and various meteorological and hydrological factors. Chronic or acute exposure may result in harassment, harm, or mortality of sea turtles occurring in the northern Gulf. Exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick are expected to most often result in sublethal impacts (e.g., decreased health and/or reproductive fitness, increased vulnerability to disease) to sea turtles. Sea turtle hatchling exposure to, fouling by, or consumption of tarballs persisting in the sea following the dispersal of an oil slick would likely be fatal.

The oil from an oil spill can adversely affect sea turtles by causing soft tissue irritation, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats. The long-term impacts to sea turtle populations are poorly understood but could include decreased survival and lowered reproductive success. The range of toxicity and degree of sensitivity to oil hydrocarbons and the effects of cleanup activities on sea turtles are unknown. Impacts from the dispersants are unknown, but may have similar irritants to tissues and sensitive membranes as they are known to have had on seabirds and marine mammals (NRC, 2005).

In accordance with the Incidental Take Statement, NMFS believes that a small number of listed species would experience adverse effects as the result of exposure to a large oil spill or ingestion of accidentally spilled oil over the lifetime of proposed CPA Lease Sale 216/222. However, NMFS is not

including an Incidental Take Statement for the incidental take of listed species due to oil exposure. Incidental take, as defined at 50 CFR 402.02, refers only to takings that result from an otherwise lawful activity. The Clean Water Act (33 U.S.C. 1251 et seq.), as amended by the Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.), prohibits discharges of harmful quantities of oil, as defined at 40 CFR 110.3, into waters of the United States. Therefore, even though the Biological Opinion (USDOC, NMFS, 2007b) considered the effects on listed species by oil spills that may result from proposed CPA Lease Sale 216/222, those takings that would result from an unlawful activity (i.e., oil spills) are not specified in the Incidental Take Statement and have no protective coverage under Section 7(o)(2) of the ESA.

The DWH event and related spill-response activities may impact sea turtles that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected sea turtle environment. For the latest available information on oiled or affected sea turtles documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c). **Figure 4-13** summarizes sea turtles collected by date obtained from the consolidated numbers of collected fish and wildlife that have been reported to the Unified Area Command from FWS, NOAA, incident area commands, rehabilitation centers, and other authorized sources operating within the DWH event impact area through November 2, 2010. More detail on the potential range of effects to sea turtles from contact with spilled oil can be found on the NMFS Office of Protected Resources website (http://www.nmfs.noaa.gov/pr/health/oilspill/turtles.htm). The NRDA-related efforts are ongoing, and the results will be incorporated into future environmental analyses.

A similar yet not comparable blowout of the *Ixtoc I* offshore drilling rig in the Bay of Campeche, Mexico, on June 3, 1979, resulted in the release of 500,000 metric tons (140 million gallons) and the transport of this oil into the Gulf of Mexico (ERCO, 1982). Of the three sea turtles found dead in the U.S., all had petroleum hydrocarbons in the examined tissues, and there was selective elimination of portions of this oil, indicating chronic exposure (Hall et al., 1983).

Summary and Conclusion

The BOEMRE has reexamined the analysis for sea turtles presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and has considered the recent reports cited above and other new information. The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. With current regulations, mitigation, and the low probability of an accidental event, effects on turtle populations from a CPA proposed action are expected to be small.

In the event of a catastrophic spill similar to the DWH event, any substantive impact to sea turtles is very unlikely because the potential impacts from a catastrophic spill would be similar to aforementioned routine and accidental issues. However, despite the recent DWH event, historical trends in the GOM indicate that catastrophic spill events are not likely to occur as a result of drilling and temporary abandonment associated with the CPA proposed action.

4.1.1.12.4. Cumulative Impacts

A detailed impact analysis of sea turtles for the CPA proposed action can be found in Chapter 4.5.6 of the Multisale EIS and in Chapter 4.1.7.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

The major impact-producing factors resulting from cumulative activities associated with the CPA proposed action that may affect loggerhead, Kemp's ridley, hawksbill, green, and leatherback turtles and their habitats include the degradation of water quality resulting from operational discharges; vessel traffic; noise generated by platforms, drillships, helicopters and vessels; seismic surveys; explosive structure removals; oil spills; oil-spill-response activities; loss of debris from service vessels and OCS structures; commercial fishing; capture and removal; and pathogens. The cumulative impact of these ongoing OCS activities on sea turtles is expected to result in a number of chronic and sporadic sublethal effects (i.e., behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) because that may stress and/or weaken individuals of a local group or population and may predispose them to infection from natural or anthropogenic sources.

Few deaths are expected from chance collisions with OCS service vessels, ingestion of plastic material, commercial fishing, and pathogens. Disturbance (noise from vessel traffic and drilling operations, etc.) and/or exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal during their life cycle. The net result of any disturbance depends upon the size and percentage of the population likely to be affected, the ecological importance of the disturbed area, the environmental and biological parameters that influence an animal's sensitivity to disturbance and stress, or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980). As discussed above, lease stipulations and regulations are in place to reduce vessel strike mortalities.

Incremental injury effects from the proposed action on sea turtles are expected to be negligible for drilling and vessel noise and minor for vessel collisions, but the effects will not rise to the level of significance because of the limited scope, duration, and geographic area of the proposed drilling and vessel activities and the relevant regulatory requirements.

The effects of the proposed action, when viewed in light of the effects associated with other relevant activities, may affect sea turtles occurring in the GOM. With the enforcement of regulatory requirements for drilling and vessel operations and the scope of the proposed action, incremental effects from the proposed drilling activities on sea turtles will be negligible (drilling and vessel noise) to minor (vessel strikes). The best available scientific information indicates that sea turtles do not greatly use sound in the environment for survival; therefore, disruptions in environmental sound would have little effect. Consequently, no significant cumulative impacts would be expected from the CPA proposed activities or as the result of past, present, or reasonably foreseeable oil and gas leasing, exploration, development and production in the GOM.

Summary and Conclusion

The BOEMRE has reexamined the analysis for sea turtles presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and has considered the recent reports cited above and other new information. While new information discloses significant cumulative impacts on sea turtles as a result of tropical storms and longline fishing, the incremental contribution of the CPA proposed action to those cumulative impacts remains as described in the Multisale EIS and the 2009-2012 Supplemental EIS and still would not have a population-level effect on the species. The analysis and potential impacts detailed in the Multisale EIS and the 2009-2012 Supplemental EIS still apply for proposed CPA Lease Sale 216/222. Because of current regulations, mitigation, and the low probability of an accidental event, effects on turtle populations from the CPA proposed action are expected to be small and should not elevate cumulative effects from natural and anthropogenic sources.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing

consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

4.1.1.13. Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice

The BOEMRE has reexamined the analysis for beach mice presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for beach mice presented in the Multisale EIS. Due to the extended distance from shore, activities occurring in the 181 South Area are not expected to impact beach mice.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A brief summary of potential impacts follows. An impact from consumption of beach trash and debris associated with the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but unlikely. While potential spills that could result from the CPA proposed action are not expected to contact beach mice or their habitats, large-scale oiling of beach mice could result in local extinction and, if not properly regulated, oil-spill-response and cleanup activities could have a significant impact to the beach mice and their habitat. Cumulative activities posing the greatest potential harm to beach mice are non-OCS factors and natural catastrophes, which, in combination, could potentially deplete some beach mice populations to unsustainable levels. The expected incremental contribution of the CPA proposed action to the cumulative impacts is negligible. Because beach mice are located such a far distance from the proposed CPA sale area, the impacts of the CPA proposed action have not been analyzed.

4.1.1.13.1. Description of the Affected Environment

A detailed description of beach mice can be found in Chapter 3.2.5 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.8 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Hall (1981) recognizes 16 subspecies of field mouse (*Peromyscus polionotus*), 8 of which are collectively known as beach mice. Of Gulf Coast subspecies, the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice occupy restricted habitats in the mature coastal dunes of Florida and Alabama. All four mice are listed as endangered: the Alabama subspecies in Alabama (listed June 6, 1985); and the Perdido Key subspecies (June 6, 1985), St. Andrew subspecies (December 18, 1998), and Choctawhatchee subspecies (June 6, 1985) in Florida (USDOI, FWS, 1985a, 1987, and 1998). Populations have fallen to levels approaching extinction. For example, in the late 1980's, estimates of total remaining beach mice were less than 900 for the Alabama beach mouse, about 80 for the Perdido Key beach mouse, and about 500 for the Choctawhatchee beach mouse. The St. Andrew beach mouse is the only listed subspecies without designated critical habitat.

Continued monitoring of populations of all subspecies along the Gulf Coast between 1985 and the present indicates that approximately 32.3 mi (52 km) of coastal dune habitat are now occupied by the four listed subspecies (1/3 of historic range). Beach mice were listed because of the loss of coastal habitat from human development. The reduced distribution and numbers of beach mice have continued because of multiple habitat threats over their entire range (coastal development and associated human activities, military activities, coastal erosion, and sea states caused by severe weather). Habitat loss is the primary cause for declines in populations of beach mice (USDOI, FWS, 2006a). Development of beachfront real estate along coastal areas and catastrophic alteration by hurricanes are the primary contributors to loss of habitat. Destruction of Gulf Coast sand dune ecosystems for commercial and residential development has destroyed about 60 percent of original beach mouse habitat (Holliman, 1983). Recent studies indicate that this continues to be a problem (Douglass et al., 1999; South Alabama Regional Planning Commission, 2001).

The inland extent of beach mouse habitat may vary depending on the configuration of the sand dune system and the vegetation present. There are commonly several rows of dunes paralleling the shoreline and within these rows there are generally three types of microhabitat. The first microhabitat is the frontal

dunes (from the beach face proceeding inland, these compose the primary and secondary dunes). These features are sparsely vegetated with widely scattered coarse grasses including sea oats (*Uniola paniculata*), bunch grass (*Andropogon maritimus*), and beach grass (*Panicum amarum* and *P. repens*), and with seaside rosemary (*Ceratiola ericoides*), beach morning glory (*Ipomoea stolonifera*), and railroad vine (*I. Pes-caprae*). Primary and secondary dunes only differ in location relative to the beach. The second microhabitat is the higher rear scrub dunes (tertial dunes), which support growth of slash pine (*Pinus elliotti*), sand pine (*P. clausa*), and scrubby shrubs and oaks, including yaupon (*Ilex vomitoria*), marsh elder (*Iva sp*.), scrub oak (*Quercus myrtifolia*), and sand-live oak (*Q. virginiana* var. *maritima*). The third microhabitat is the interdunal areas, which contain sedges (*Cyperus sp*.), rushes (*Juncus scirpoides*), and salt grass (*Distichlis spicata)*.

Beach mice are restricted to the coastal barrier sand dunes along the Gulf. Optimal overall beach mouse habitat is currently thought to be comprised of a heterogeneous mix of interconnected habitats including frontal dunes, scrub (tertiary) dunes farther inland, and interdunal areas between these dune habitats, as discussed above. Beach mice dig burrows mainly in the frontal dunes and interior scrub dunes where the vegetation provides suitable cover. Most beach mouse surveys conducted prior to the mid-1990's were in primary and secondary frontal dunes because the investigators assumed that these habitats are the preferred habitat of beach mice. A limited number of surveys in scrub dunes and other interior habitat resulted in less knowledge of the distribution and relative abundance there. In coastal environments, the terms "scrub" and "scrub dune" refer to habitat or vegetation communities adjacent to and landward of primary and secondary dune types where scrub oaks are visually dominant. Interior habitat can include vegetation types such as grass-like forbs (forbs are the herbs other than grasses). There is substantial variation in scrub oak density and cover within and among scrub dunes throughout ranges of beach mice. The variation, an ecological gradient, is represented by scrub oak woodland with a relatively closed canopy at one end of a continuum. At the other extreme of the gradient, scrub dunes are relatively open with patchy scrub ridges and intervening swales or interdunal flats dominated by herbaceous plants.

Beach mice feed nocturnally in the dunes and remain in burrows during the day. Their diets vary seasonally but consist mainly of seeds, fruits, and insects (Ehrhart, 1978; Moyers, 1996). Changes in the availability of foods result in changes in diets between seasons and account for variability of seasonal diets between years. Autumn diets of beach mice consist primarily of seeds and/fruits of sea oats, evening primrose (*Oenothera humifusa*), bluestem (*Schizachyrium maritimum*), and dune spurge (*Chamaesyce ammannioides*). Sea oats and beach pea (Galactia sp.) dominate winter diets. Spring diets primarily consist of dune toadflax (*Linaria floridana*), yaupon holly (*Ilex vomitoria)*, seashore elder (*Iva imbricata*), and greenbrier (*Smilax sp.*). Summer diets are dominated by evening primrose, insects, dune toadflax, and ground cherry (*Physalis augustifolia*) (Moyers, 1996). Management practices designed to promote recovery of dune habitat, increase food sources, and enhance habitat heterogeneity may aid in the recovery of beach mouse populations.

In wild populations, beach mice have an average life span of about 9 months. Males and females reach adulthood and are able to reproduce at approximately 35 days of age. Females can nurse one litter while pregnant with another litter. From captive colonies we know that litter size is 1-8 with an average of four. Young are weaned in 2-3 weeks and are generally on their own 1-2 weeks later.

Hurricanes are a natural environmental phenomenon affecting the Gulf Coast, and beach mice have evolved and persisted in coastal dune habitats since the Pleistocene. Hurricanes are part of a repeated cycle of destruction, alteration, and recovery of dune habitat. The extensive coastal dune habitat that existed along the Gulf Coast before the fairly recent commercial and residential development allowed beach mice to survive even the most severe hurricane events to repopulate dune habitat as it recovered. Beach mice are affected by the passage of hurricanes along the northwest Florida and Alabama Gulf Coast. Since records on hurricane intensity began in 1885, over 30 hurricanes have struck northwest Florida within the historic ranges of the four Gulf Coast beach mouse subspecies (Williams and Duedall, 1997; Doering et al., 1994; Neumann et al., 1993). In addition, 22 hurricanes have made landfall along the coast of Alabama from 1851 to 2004 (USDOC, NOAA, National Hurricane Center, 2006).

Hurricanes generally produce damaging winds, storm tides and surges, and rain that erode barrier-island, peninsular, and mainland beaches and dunes. Hurricanes cause increased fragmentation of habitat, which is correlated with increased distance between fragments that must be crossed by beach mice at night if they are to move between habitat patches. Gap distance travelled may decrease when visibility is

poor during the new moon, making predators harder to see (Wilkinson et al., 2009). Gap distance travelled may increase if beach mice know in advance that the target patch is environmentally more favorable, making risk of predation worthwhile (Wilkinson et al., 2009). Following hurricanes, the dune system begins a slow natural repair process that may take 3-20 years, depending on the magnitude of dune loss (Salmon et al., 1982). During this period, sea oats and pioneer dune vegetation become established, collecting sand and building dunes. As the dunes grow and become stable, other successional dune vegetation colonizes the area (Gibson and Looney, 1994), and beach mouse food sources and habitats are reestablished. The rate of recovery of food supplies for beach mice is variable, with some areas adversely affected for an extended period of time by hurricane and post-hurricane conditions.

Tropical storms periodically devastate Gulf Coast sand dune communities, dramatically altering or destroying habitat, and either drowning beach mice or forcing them to concentrate on high scrub dunes where they are exposed to predators. How a hurricane affects beach mice depends primarily on its characteristics (winds, storm surge, rainfall), the time of year (midsummer is the worst), where the eye crosses land (side of hurricane—clockwise or counterclockwise), population size, and storm impacts to habitat and food sources. The interior dunes and related access corridors may be essential habitats for beach mice following survival of a hurricane. For the three subspecies that have critical habitat areas (Alabama, Perdido Key, and Choctawhatchee beach mice), the major constituent elements that are known to require special management considerations or protection are dunes and interdunal areas and associated grasses and shrubs that provide food and cover (USDOI, FWS, 1985a and b).

Beach mice have existed in an environment subject to recurring hurricanes, but tropical storms and hurricanes are now considered to be a primary factor in the beach mouse's decline. It is only within the last 20-30 years that the combination of habitat loss due to beachfront development, isolation of remaining beach mouse habitat areas and populations, and destruction of remaining habitat by hurricanes have increased the threat of extinction of several subspecies of beach mice.

The FWS reported considerable damage to 10 national wildlife refuges in Alabama, Mississippi, Louisiana, and the Panhandle of Florida caused by Hurricane Ivan in 2004 (USDOI, FWS, 2004a). Perdido Key, Florida, was hit hard by Hurricane Ivan, and beach mouse dune habitat and populations were greatly reduced. The mice take refuge on higher ground during severe storms. Hurricane Ivan adversely impacted an estimated 90-95 percent of primary and secondary dune habitat throughout the range of the Alabama beach mouse (USDOI, FWS, 2004b). Trapping data indicate that mice may have become locally extinct in these low-lying areas (USDOI, FWS, 2004b). Approximately 3,460 ha (1,400 ac) of higher elevation scrub habitat did not appear to be inundated by storm surge from either Hurricanes Ivan or Katrina (U.S. Dept. of the Army, COE, 2002a; USDOI, FWS, 2004b, 2004c, and 2005a; ENSR Corporation, 2004) but received moderate damage from salt spray and wind (Boyd et al., 2003; USDOI, FWS, 2004a). The worst damage from Hurricane Ivan occurred in Alabama to Bon Secour National Wildlife Refuge located west of Gulf Shores, Alabama, along the Fort Morgan Peninsula. Major primary dunes at Bon Secour were almost completely destroyed and tons of debris washed up on the refuge.

Following Hurricane Opal in 1995, Swilling et al. (1998) reported higher Alabama beach mouse densities in the scrub than the foredunes nearly 1 year after the storm. As vegetation began to recover, however, the primary and secondary dunes were reoccupied by Alabama beach mice, and population densities surpassed those in the scrub in the fall and winter following the storm. Similar movement and habitat occupation patterns were observed following Hurricane Georges in 1998. Therefore, while Alabama beach mouse numbers and habitat quality in the frontal dunes ebb and flow in response to tropical storms, the higher elevation scrub habitat is important to mouse conservation as a more stable environment during and after storm events.

In a population genetics study of the Alabama beach mouse, adult males were often trapped with adult females, probably their mates in this monogamous species (Tenaglia et al., 2007). These pairs were more distantly related than expected, probably because kin recognition allowed selection of unrelated mates to avoid inbreeding depression as a result of breeding of related individuals. Inbreeding depression is an increase in the frequency of harmful homozygous recessive genes, which cause reduced fitness of a population. As population levels have declined, inbreeding avoidance has become important to this subspecies. Subadults were often captured with related mice, suggesting that mice form sibling and adult-subadult familial bonds before final adult dispersal, which itself is a short distance (Tenaglia et al., 2007). Consequences for inbreeding impacts remain to be investigated.

The DWH event has so far had no recorded environmental changes for the Alabama beach mouse and probably no ecological changes yet for the other three subspecies (Leblanc, personal communication, 2010). No changes have yet occurred on the two subspecies of beach mice on the Atlantic Coast of Florida. No oil has yet been reported as entering the Loop Current to reach the east coast of Florida. Vehicular traffic and activity associated with the DWH event cleanup can trample or bury nests and burrows or cause displacement from preferred habitat. Sometimes, because of lack of thorough training of all personnel, future vehicle and foot traffic that may take place during shoreline cleanup resulting from the DWH event could disturb beach mouse populations or degrade or destroy habitat. A study is pending (due out in January or February 2011) in part investigating events where bulldozers in Florida allegedly breached possible beach mouse dune habitat so cleanup vehicles could reach oiled beaches (Frater, personal communication, 2010).

4.1.1.13.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of beach mice for the CPA proposed action can be found in Chapter 4.2.2.1.7 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.8.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

This chapter discusses the possible effects of routine activities associated with the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice, which are designated as protected species under the Endangered Species Act (**Chapter 1.3**). The mice occupy restricted habitat behind coastal foredunes of Florida and Alabama (Ehrhart, 1978; USDOI, FWS, 1987). Portions of the beach mouse habitat have been designated as critical.

Proposed Action Analysis

The major impact-producing factors associated with routine activities of the proposed action that may affect beach mice include beach trash and debris, and efforts undertaken for the removal of marine debris or for beach restoration. Beach mice may mistakenly consume trash and debris. Mice may become entangled in the debris. The proposed action is expected to contribute negligible marine debris or disruption to beach mice areas. Their burrows are about 1-3 m (3-10 ft) long and involve a plugged escape tunnel, which would function if the main burrow entrance was trampled by foot traffic (beach mice would dig themselves out through the plug) of insufficiently trained debris cleanup personnel (Mitchell, personal communication, 2010).

Summary and Conclusion

An impact from the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice is possible but unlikely. Impact may result from consumption of beach trash and debris. Because the proposed action would deposit only a small portion of the total debris that would reach the habitat, the impacts would be minimal. Unless all personnel are adequately trained, efforts undertaken for the removal of marine debris may temporarily scare away beach mice or destroy their food resources such as sea oats. However, their burrows are about 1-3 m (3-10 ft) long and involve a plugged escape tunnel, which would function after the main burrow entrance was trampled by foot traffic of insufficiently trained debris cleanup personnel.

4.1.1.13.3. Impacts of Accidental Events

A detailed impact analysis of beach mice for the CPA proposed action can be found in Chapter 4.4.7 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.8.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the

2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

This chapter discusses the possible effects of accidental activities associated with the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice, which are designated as protected species under the Endangered Species Act. The major impact-producing factors resulting from the accidental activities associated with the CPA proposed action that may affect beach mice include offshore and coastal oil spills, and spill-response activities.

The oiling of beach mice could result in local extinction, but this is very unlikely, given the chance of impact to the habitat is <0.5 percent, and the area of viable habitat is broad relative to the area potentially contacted by a large spill.

For the CPA proposed action, which is based on the 2009-2012 Supplemental EIS OSRA model, the probabilities remain low (<0.5%) that one or more offshore spills ≥1,000 bbl would occur and contact the shoreline inhabited by the Alabama, Choctawhatchee, St. Andrews, and Perdido Key beach mice during the 40-year life of the proposed action. Spills in coastal waters could occur at storage or processing facilities and at service bases supporting the proposed action; however, these facilities would not likely be located near beach mouse habitat.

Recovery of habitat from hurricanes involves a vital link between mouse food supply (involving seeds of dune-stabilizing vegetation) and habitat. The link is not unique to the beach mouse (it may occur in many habitats) and may be lost after an oil spill; this loss may result in extinction of the beach mouse after later serious storms or hurricanes or further beachfront development disrupts habitat. Impacts can also occur from spill-response activities. Vehicular traffic and other activities associated with oil-spill cleanup can degrade preferred habitat and cause displacement of mice from these areas.

There is no definitive information on the persistence of oil in the event that a spill was to contact beach mouse habitat. In Prince William Sound, Alaska, after the *Exxon Valdez* spill in 1989, buried oil has been measured in the intertidal zone of beaches, but no effort has been made to search for residual buried oil above high tide. Similarly, NRC (2003) makes no mention of studies of oil left above high tide after a spill. Regardless of the potential for persistence of oil in beach mouse habitat, a slick cannot wash over the foredunes unless carried by a heavy storm swell.

Summary and Conclusion

The oiling of beach mice could result in local extinction. Oil-spill-response and cleanup activities could also have a substantial impact to the beach mice and their habitat if not properly regulated. However, potential spills that could result from the proposed action are not expected to contact beach mice or their habitats (<0.5% probability). Also, inshore facilities related to the proposed action are unlikely to be located on beach mouse habitat.

Within the last 20-30 years, the combination of habitat loss due to beachfront development, isolation of remaining beach mouse habitat areas and populations, and destruction of remaining habitat by tropical storms and hurricanes has increased the threat of extinction of several subspecies of beach mice. Destruction of the remaining habitat due to a catastrophic spill and cleanup activities would increase the threat of extinction, but the potential for a catastrophic spill that would affect beach mice habitat is low.

The BOEMRE has reexamined the analysis for impacts to beach mice. No substantial new information was found at this time that would alter the overall conclusion that impacts on beach mice from accidental impacts associated with the CPA proposed action would be minimal.

4.1.1.13.4. Cumulative Impacts

A detailed impact analysis of beach mice for the CPA proposed action can be found in Chapter 4.5.7 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.8.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS,; the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

This chapter discusses the possible cumulative activities associated with the CPA proposed action on the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice, which are designated as protected species under the ESA. Cumulative activities have a potential to harm or reduce the numbers of beach mice. The major impact-producing factors resulting from the cumulative activities associated with the CPA proposed action that may affect beach mice include oil spills, alteration and reduction of habitat, predation and competition, and consumption of beach trash and debris. Most proposed action-related spills, as well as oil spills stemming from import tankering and prior and future lease sales, are not expected to contact beach mice or their habitats. Cumulative activities posing the greatest potential harm to beach mice are non-OCS factors (i.e., beach development, domestic cats, and coastal spills) and natural catastrophes (i.e., hurricanes and tropical storms), which, in combination, could potentially deplete some beach mice populations to unsustainable levels. The expected incremental contribution of the CPA proposed action to the cumulative impacts is negligible.

The results of a baseline Population and Habitat Viability Analysis (PHVA) model of the Alabama beach mouse (Traylor-Holzer et al., 2005) suggest that the Alabama beach mouse metapopulation has an 18-21 percent probability of extinction over 100 years, depending on whether the habitat recovers slowly or quickly following hurricanes. Sensitivity tests for the model give probabilities of extinction of 13-36 percent over 100 years. Habitat restoration reduces the probability of Alabama beach mouse extinction at or immediately following a hurricane. Recolonization by translocation could eliminate the possibility of Alabama beach mouse extinction. A relatively small number of domestic cats would result in virtually certain extinction of the Alabama beach mouse. Development scenarios have, at most, minor impacts on the estimates of probabilities of Alabama beach mouse extinction.

Many of the model parameters were uncertain and may have been inaccurate, resulting in uncertainty in the probability of Alabama beach mouse extinction. Revision of the model using data collected after Hurricane Ivan (Traylor-Holzer, 2005) projects a 14 percent risk of extinction over the next 100 years. Much of the risk is from hurricanes. None of the revised development scenarios result in certain Alabama beach mouse extinction. The highest risk from development is a 34 percent chance of extinction over 100 years. Under the revised model, habitat restoration efforts are unlikely to substantially reduce or eliminate extinction risk. Data collected after Hurricane Katrina were used in a second revision of the model (Reed and Traylor-Holzer, 2006). The revised model projects a risk of extinction of 26.8 ± 1.0 percent over the next 100 years. Destruction of migration corridors between populations raises the risk to 41.2 ± 1.1 percent, but only 34.9 ± 1.1 percent with the translocation of mice. Total loss of private land as suitable habitat raises the risk further to 46.8 ± 1.1 percent, but only 40.8 ± 1.1 percent with the translocation of mice. Hanski (1999) warns that simpler metapopulation models, such as that done for the Alabama beach mouse, are more reliable than PVHA models because predictions of PHVA and Population Viability Analysis models cannot be tested (only intrinsic sensitivity to changes in various parameters can be tested). The Incidence Function Model is an example of a testable metapopulation model (Hanski, 1999).

No recent information was found that would necessitate a reanalysis of the cumulative impacts of the proposed action upon the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice. Due to the extended distance from shore, the incremental impacts associated with activities are not expected to impact beach mice.

Summary and Conclusion

Cumulative activities have a potential to harm or reduce the numbers of Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice. Those activities include oil spills, alteration and reduction of habitat, predation and competition, and consumption of beach trash and debris. Most spills related to the proposed action, as well as oil spills stemming from import tankering and prior and future lease sales, are not expected to contact beach mice or their habitats. This is because of the distance of the CPA proposed action to beach mice habitat. Cumulative activities posing the greatest potential harm to beach mice are non-OCS activities (beach development and coastal spills) and natural catastrophes (hurricanes) which, in combination, could potentially deplete some beach mice populations to unsustainable levels. Impacts from the CPA proposed action could come from trash and debris and effort to remove them, as well as oil

spills and cleanup operations. If personnel are properly trained and supervised, these impacts could be reduced. The expected incremental contribution of the CPA proposed action to the cumulative impacts is negligible.

Following the DWH event, BOEMRE requested reinitiation of ESA consultation with both NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010. The FWS responded with a letter to BOEMRE on September 27, 2010. The reinitiated consultations are not complete at this time, although BOEMRE is in discussions with both agencies.

4.1.1.14. Coastal and Marine Birds

The BOEMRE has reexamined the analysis for coastal and marine birds presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for coastal and marine birds presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. The majority of impacts resulting from routine activities associated with the CPA proposed action on endangered/and nonendangered/nonthreatened coastal and marine birds are expected to be sublethal. These impacts include behavioral effects, exposure to or intake of OCS-related contaminants or discarded debris, temporary disturbances, and displacement of localized groups from impacted habitats. Impacts from potential oil spills associated with the proposed action and oil-spill cleanup on birds are expected to be negligible; however, small amounts of oil can affect birds, and there are possible delayed impacts on their food supply. The effect of cumulative activities on coastal and marine birds is expected to result in a discernible decline in the numbers of birds that form localized flocks or populations, with associated changes in species composition and distribution. The incremental contribution of the proposed action to cumulative impacts is expected to be negligible because it would not seriously alter species composition and cause major reductions in the overall carrying capacity of disturbed areas.

4.1.1.14.1. Description of the Affected Environment

A detailed description of coastal and marine birds can be found in Chapter 3.2.6 of the Multisale EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared. A search of Internet bibliographic databases, as well as personal interviews with authors of references used in the Multisale EIS, was conducted to determine the availability of recent information since publication of the Multisale EIS. No new information on the description of bird resources was found from these information sources and/or the DWH event.

Nonendangered and Nonthreatened Species

A detailed description of bird species, colonial breeding, and foraging habits of nonendangered and nonthreatened coastal and marine birds can be found in Chapter 3.2.6.1 of the Multisale EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, which incorporates new information found since the publication of these documents.

The Gulf of Mexico is populated by both resident and migratory species of coastal and marine birds (Parnell et al., 1988; Visser and Peterson, 1994; Mikuska et al., 1998; Miller and Fontenot, 2001; Rappole, 2006). They are herein separated into seven major groups: diving birds, seabirds, shorebirds, passerines, marsh and tall wading birds, waterfowl, and raptors. Many species are mostly pelagic and, therefore, are rarely sighted near shore. The remaining species are found within coastal and inshore habitats and are more susceptible to potential deleterious effects resulting from OCS-related activities (Clapp et al., 1982). Previous surveys indicate that Louisiana and Texas are among the primary states in the southern and southeastern U.S. for both nesting colonies and total number of breeding coastal and marine birds (Martin and Lester, 1991; Martin, 1991).

Diving Birds

Diving seabirds are discussed separately in the seabirds section and diving ducks are discussed in the waterfowl section. Diving birds are a diverse group. There are three main groups of diving birds: cormorants and anhingas (Pelecaniformes), loons (Gaviiformes), and grebes (Podicipediformes). The only representative diving bird known to breed in the Gulf is the cormorant. The common diving birds in the northern GOM are listed with their main features in Table 3-6 of the Multisale EIS.

Seabirds

Three taxonomic orders contain seabirds (defined as species that spend a large portion of their lives on or over seawater) in the offshore waters of the northern Gulf of Mexico: (1) Procellariiformes (albatrosses, petrels, shearwaters, and storm-petrels); (2) Pelecaniformes (frigatebirds, tropicbirds, gannets, brown pelican, and boobies); and (3) Charadriiformes (phalaropes, skuas and jaegers, gulls, and terns) (Clapp et al., 1982; Harrison, 1983; Warham, 1990; Olsen and Larsson, 1995 and 1997; Peake et al., 1995; Harrison, 1996; National Geographic Society, 1999). The brown pelican was removed from the threatened and endangered list on November 17, 2009 (*Federal Register*, 2009d). The species is still protected under the Migratory Bird Treaty Act and also has special conservation status in all coastal states except Alabama. Colonies of laughing gulls, eight species of terns, and black skimmers nest in the Gulf (Martin and Lester, 1991; Pashley, 1991). A census of south Louisiana seabird nesting colonies was completed in 2001 (Michot et al., 2003). Collectively, many seabirds live far from land most of the year, roosting on the water surface, except at breeding time when they return to nesting areas along coastlines (Terres, 1991). Seabirds typically aggregate in social nesting groups called colonies; the degree of colony formation varies among species. Much of the deep ocean is relatively devoid of avifauna because of low concentrations of nutrients for phytoplankton. However, certain oceanic conditions including upwelling, convergences, divergences, specific sea-surface temperatures, thermal fronts, salinities, areas of high planktonic productivity, or current activity create veritable oases for foraging seabirds. Seabirds obtain their food through a variety of behaviors including kleptoparasitism, scavenging, dipping, plunge diving, and surface feeding. Impacts of widespread dispersed oil from the DWH event may have had serious impacts on pelagic birds feeding in oiled waters and/or on oiled prey. The baseline for pelagic birds in the affected environment of the proposed action may have been negatively affected. Nesting terns include Caspian (*Sterna caspia)*, royal (*S. maxima*), sandwich (*S. sandvicensis*), common (*S. hirundo*), Forster's (*S. forsteri*), coastal least (*S. antillarum*), gull-billed (*Sterna nilotica*), and sooty (*S. fuscata*). All of the terns nesting in the GOM, as well as the Arctic tern (*S. paradisaea*), bridled tern (*S. anaethetus*), black tern (*Chlidonias niger*), brown noddy (*Anous stolidus*), and black noddy (*Anous minutus*), are found in blue water in the northern GOM (Cardiff, personal communication, 2006). Most of these species forage exclusively on small fish and feed by plunge diving, often from a hovering position. Terns, and gannets and boobies (*Sula* spp.) as well, are streamlined for plunge diving and the underwater pursuit of fish. All seabirds are colonial nesters and all evolved from colonial land birds. Most land birds are not colonial nesters (Lack, 1968). A discussion of the colonial breeding of seabirds is relevant to their increased potential vulnerability to anthropogenic noise, as presented in Chapter 3.2.6.1 of the Multisale EIS. The collective feeding characteristic of many colonial nesters and other birds is also discussed. The small body-size of terns is a factor in their vulnerability to OCS-related activities and their general ecology, as discussed in the Multisale EIS.

Shorebirds

Shorebirds are members of the order Charadriiformes and are generally restricted to coastline and inland water margins (e.g., beaches, mudflats, etc.). The Gulf of Mexico shorebirds comprise five taxonomic families: Jacanidae (jacanas), Haematopodidae (oystercatchers), Recurvirostridae (stilts and avocets), Charadriidae (plovers), and Scolopacidae (sandpipers, snipe, and allies) (Hayman et al., 1986). Most of the shorebirds are solitary nesters. Along the central Gulf Coast, 44 species of shorebirds have been recorded. However, only 6 species are known breeders in the area; the remaining 38 species are considered winter residents and/staging migrants (Pashley, 1991).

Many of the overwintering shorebird species remain within specific areas throughout the season and exhibit among-year wintering site fidelity, at least when not disturbed by humans. These species may be

especially susceptible to localized impacts, resulting in habitat loss or degradation unless they move to more favorable habitats when they are disturbed by humans.

An important characteristic of almost all shorebird species is their strongly developed migratory behavior, with some shorebirds migrating from nesting places in the high Arctic tundra to the southern part of South America (Morrison 1984; Terres, 1991; Morrison et al., 2000, 2001, and 2006). Their migratory abilities expose them to a constraint perhaps more than other, less capable migrants. A recent study shows that all Arctic-breeding shorebirds (worldwide) tend to avoid migration routes that require individuals to negotiate barriers, including the Arctic Ocean itself, where landing and feeding cannot take place (Henningsson and Alerstam, 2005).

Both spring and fall migrations take place in a series of stops among various staging areas where birds spend time feeding heavily to store up fat for the sustained flight to the next staging area (Skagen and Knopf, 1993; Deleon and Smith, 1999; Farmer and Durbian, 2006; Krapu et al., 2006; Skagen et al., 2008); many coastal habitats along the GOM are critical for such purposes. Shorebird species of conservation concern in coastal Louisiana are dunlin, short-billed dowitcher, marbled godwit, American oystercatcher, and the piping, Wilson's, and snowy plovers. Birds that migrate through or winter along the northern Gulf of Mexico in fall may have just experienced impacts from the DWH event, and it is not yet clear if any bird taxa will be altered by the spill. Many transients, including most calidrid sandpipers, nest in Arctic Canada and Alaska. They feed on insects, a variety of marine and freshwater invertebrates, fish, and small amounts of plant life. Coastal sandpipers may not find adequate food in nontidal habitats with a static shoreline because of insufficient size of invertebrate forage populations.

Shorebirds, including sandpipers, have adapted to utilize highly ephemeral habitats, including advancing and/or receding with the changing shoreline of wetlands transiently exposed over a substantially greater area (relative to narrow, linear, nontidal wetlands) to lunar, solar, or wind-driven tides. Sandpiper legs are moderately long for wading and foraging just seaward of the shoreline, and their bills and necks are moderately long for pecking on small invertebrates on the sediment surface or probing beneath the sediment. Plovers are adapted to follow solar, lunar, or wind tides in and out, foraging just landward of the water's edge. Not being waders, plovers often have relatively shorter bills, necks, and legs than sandpipers. Rising tides and low wave action would cause or facilitate accumulation of oil in intertidal vegetation and on soft-bottom flats, which are foraging grounds for these species. Substantial wave action and falling tides could offer some recurrent seaward transport of oil; such processes could ameliorate accumulation of intertidal oil.

Passerine Birds

Passerine birds mostly migrate across the Gulf of Mexico each spring and fall and are protected under the Migratory Bird Treaty Act. A study of platforms as possible resting sites for birds crossing the Gulf was completed (Russell, 2005) and is summarized in Chapter 3.2.6.1 of the Multisale EIS. Migrants sometimes arrived at certain platforms shortly after nightfall and proceeded to circle those platforms for variable periods ranging from minutes to hours. These nocturnal circulations clearly occurred because nocturnal migrants were attracted to platform light and tended to occur on overcast nights. Such circulation prevails when birds get inside the cone of light surrounding the platform and are reluctant to leave, seemingly becoming trapped by the surrounding "wall of darkness" and loss of visual cues to the horizon. Circulations put birds at risk for collision with the platform or with each other, as well as result in energetic deficits exacerbating migration-induced mortality via starvation (Russell, 2005).

Marsh and Tall Wading Birds

Collectively, the following families of tall wading birds have representatives in the northern Gulf: Ardeidae (herons and egrets), Ciconiidae (storks), Threskiornithidae (ibises and spoonbills), and Gruidae (cranes). The common wading birds in the northern GOM are listed with their main features in Table 3-7 of the Multisale EIS. A census of south Louisiana wading bird nesting colonies was completed in 2001 (Michot et al., 2003). Wading birds are those birds that have adapted to living in shallow water. They have long legs that allow them to forage by wading into shallow water, while their long bills, usually accompanied by long necks, are used to probe under water or to make long swift strokes to seize fish, frogs, aquatic insects, crustaceans, and other prey (Terres, 1991). In coastal Louisiana, species of special concern include the ardeids reddish egret, yellow-crowned night heron, and American bittern; the ciconiid

wood stork (in freshwater marshes), which is federally listed as endangered in Alabama and Florida; and the gruid whooping crane, which is federally listed as endangered in Texas and which has a planned, experimental-introduced population in Louisiana. Seventeen species of wading birds in the Order Ciconiiformes are currently known to nest in the northern Gulf coastal region, and all except the wood stork nest in the northern Gulf coastal region (Martin, 1991). Within the central Gulf Coast region, Louisiana supports the majority of nesting wading birds (Miller and Fontenot, 2001, Rappole, 2006). Nests tend to be concentrated in freshwater riparian bottomland hardwood forest wetlands. Great egrets are the most widespread nesting species in the central Gulf region (Martin, 1991), while little blue herons, snowy egrets, and tricolored herons constitute the greatest number of coastal nesting pairs in the western Gulf Coast (Texas Parks and Wildlife Department, 1990). The term "marsh bird" is a general term for a bird that lives in or around marshes and swamps. Members of the Rallidae family (rails, including moorhens, and gallinules) are labeled marsh birds and not wading birds.

Waterfowl

Waterfowl belong to the taxonomic order Anseriformes and include swans, geese, and ducks. A total of 33 species are regularly reported along the north-central and western Gulf Coast, consisting of 1 swan, 5 geese (i.e., greater white-fronted [*Anser albifrons*], Ross's [*Chen rossii*], snow [*C. caerulescens*], Canada [*Branta canadensis*], and Brant [*B. brenicla*]), 8 surface-feeding (dabbling) ducks (genus *Anas*; i.e., mallard, mottled, American wigeon, northern pintail, northern shoveler, blue-winged teal, American green-winged teal, and gadwall); 5 diving pochards (genus *Aythya*; canvasback, redhead, lesser scaup, greater scaup, and ring-necked duck), and 14 others (including the wood duck [*Aix sponsa*], fulvous whistling ducks [*Dendrocygna bicolor*], black-bellied whistling duck [*D. autumnalis*], bufflehead [*Bucephala albeola*], common goldeneye [*B. clangula*], hooded merganser [*Lophodytes cucculatus*], red-breasted merganser [*Mergus serrator*], and ruddy duck [*Oxyura jamaicensis*]) (Clapp et al., 1982b; National Geographic Society, 1999; Madge and Burn, 1988; Alsop, 2001). The common waterfowl in the northern GOM are listed with their main features in Table 3-8 of the Multisale EIS. Many species usually migrate from wintering grounds along the Gulf Coast to summer breeding grounds in the prairies, parklands, and tundra in the north. Waterfowl migration pathways have traditionally been divided into four parallel north-south paths, or "flyways," across the North American continent (Bellrose 1980). The Gulf Coast serves as the southern terminus of both the Central (Texas) and Mississippi (Louisiana, Mississippi, and Alabama) flyways, and winters an estimated 8-10 million ducks, 500,000 geese, and 1-1.5 million American coots (Bellrose, 1980; Chabreck et al., 1989; Hobaugh et al., 1989; Stuzenbacker and Weller, 1989). Waterfowl are highly social and possess a diverse array of feeding adaptations related to their habitat (Johnsgard, 1975; Poysa, 1983; Nudds, 1983 and 1992). Waterfowl young are precocial, leaving their nests relatively soon after they hatch and, thus, they are capable of swimming and feeding. Most waterfowl species in the northern Gulf of Mexico are winter residents and migrate far to the north to breed (Sibley, 2000; Alsop, 2001). Herbivorous geese must eat relatively more food than most omnivorous or carnivorous waterbirds like ducks. Geese digest little of the vegetation they gorge on because much of it is indigestible. Feces can provide immediate cycling of nitrogen in nitrogen-limited vegetation.

Raptors

The American peregrine falcon was removed from the endangered species list on August 25, 1999 (*Federal Register*, 1999). The species is still protected under the Migratory Bird Treaty Act. The FWS will continue to monitor the falcon's status 5 times at 3-year intervals beginning in 2003 and ending in 2015 to ensure that recovery is established. The bald eagle was delisted on August 8, 2007. It is still afforded some protection under the Migratory Bird Treaty Act. The Northern harrier is listed as a species of concern in Louisiana. It forages in salt, brackish, intermediate, and fresh marsh and coastal dune-grassland shrub thicket habitat.

Effects of Hurricanes Katrina and Rita on Baseline Conditions

A detailed summary of impacts of the hurricanes on birds is provided in Chapter 3.2.6 of the Multisale EIS. Hurricanes may exacerbate impacts of OCS-related and cumulative impacts on coastal

and marine birds. Hurricanes Katrina and Rita have impacted avian habitats throughout the Gulf. Large areas of coastal wetlands have been converted to open-water habitat, potentially affecting avian species that used the wetlands for foraging, nesting, and as stopover points during migration (Gabe et al., 2005). Impacts to these habitats have the potential to result in population-level impacts affecting both abundance and distribution of some species. For example, the coastal habitats that were significantly impacted in southeastern Louisiana and the Galveston Bay area of Texas support nesting by up to 15 percent of the world's brown pelicans and 30 percent of the world's sandwich terns (Hunt, personal communication, 2006). Impacts to these habitats could reduce future nesting success and affect overall population levels of these species. Impacts to bottomland forest habitat along the Louisiana and Mississippi coasts represent further loss of avian habitat, affecting many different species; up to 70 percent of the cavity trees used by the endangered red-cockaded woodpecker at Big Branch Marsh National Wildlife Refuge in St. Tammany Parish, Louisiana, were destroyed (Hunt, personal communication, 2006). The long-term effects of avian habitat loss because of these hurricanes is not known, and agencies including FWS and USGS are implementing numerous studies and monitoring programs to determine the extent and magnitude of impacts to affected avian populations.

After Hurricane Rita, the Chenier Plain in western Louisiana was sampled for plant and animal food for neotropical migrant birds. Saltwater intrusion killed almost all crawfish being raised in ponds, and it also killed freshwater vegetation there; reptiles, especially amphibians, were also killed by flooding saltwater moving inland.

Effect of the **Deepwater Horizon** *Event on Baseline Conditions*

The DWH event may have exacerbated the impacts of OCS-related and cumulative impacts on coastal and marine birds. When oil gets into vegetated or unvegetated sediment, low redox potentials, absence of light, and waterlogged substrate may mean that the oil can neither be oxidized by bacteria and sunlight nor evaporate. The oil may remain in its unweathered toxic state indefinitely. However, oil weathering as it travels to the coast ameliorates toxicity at the shoreline. The oil from the DWH event has had serious direct and indirect impacts to coastal and marine birds, but it is premature to report the welfare of any population as altered over a long period (RestoreTheGulf.gov, 2010i; **Tables 4-4, 4-5, and 4-6; Figure 4-14**).

Birds that are heavily oiled are usually killed. If physical oiling of individuals or local groups of birds occurs, some degree of both acute and chronic physiological stress associated with direct and secondary uptake of oil would be expected. Lightly oiled birds can sustain tissue and organ damage from oil ingested during feeding and grooming or from oil that is inhaled. Such birds may appear healthy, but they may be affected by stress that does not occur until much later. Stress and trauma enhance the effects of exposure and poisoning. In the Gulf of Mexico, winter resident waterfowl could suffer substantially if considerable oiling of their preferred foraging or roosting habitats occurred, primarily in coastal marshes. Substantial oiling could cause local extinction of goose populations unable to find adequate food on unoiled marshes or in agricultural fields.

Lighter PAH's like naphthalene and anthracene are volatile and water-soluble, but they are somewhat more persistent compared with lighter, more volatile, and more water-soluble hydrocarbons like benzene. Their impacts are discussed in detail in **Chapter 4.1.1.12.3**.

Endangered and Threatened Species

A detailed description of endangered and threatened coastal and marine bird species can be found in Chapter 3.2.6.2 of the Multisale EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, which incorporates new information found since the publication of these documents.

The Multisale EIS included the bald eagle in the discussion of the endangered and threatened species. However, on June 28, 2007, FWS announced the removal of the bald eagle from the list of endangered and threatened species (*Federal Register*, 2007). The FWS will work with State wildlife agencies to monitor bald eagles for at least 5 years. The FWS can propose to relist the species if it appears that bald eagles again need the protection of the Endangered Species Act. The bald eagle will continue to be protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Both Federal laws prohibit "taking" (i.e., killing, selling, or otherwise harming eagles, their nests, or eggs).

The Multisale EIS included the brown pelican in the discussion of the endangered and threatened species. However, the brown pelican was removed from the list of endangered and threatened wildlife on November 17, 2009 (USDOI, FWS, 2009).

Coastal and marine bird species that inhabit or frequent the north-central and western Gulf of Mexico coastal areas and that are recognized by FWS as either endangered or threatened include the piping plover and whooping crane.

Piping Plover

The piping plover (*Charadrius melodus*) is a migratory shorebird that is endemic to North America. The piping plover breeds along shorelines in the northern Great Plains, the Great Lakes, and along the Atlantic Coast (Newfoundland to North Carolina). It winters on the Atlantic and Gulf Coasts from North Carolina to Mexico and in the Bahamas West Indies. The final rule on critical habitat for the piping plover was published July 10, 2001; there are 20 units of critical habitat in western Florida south to Tampa Bay, 3 areas in Alabama, 15 in Mississippi, 7 in Louisiana, and 37 in Texas (*Federal Register*, 2001). Critical wintering habitat includes the land between mean low water and any densely vegetated habitat that is not used by the piping plover. The piping plover is listed as endangered on its Great Lakes breeding grounds. It is listed as threatened in the Gulf of Mexico and the rest of its wintering and breeding range. The habitats used by wintering birds include beaches, mud flats, sand flats, algal flats, and washover passes (areas where breaks in the sand dunes result in an inlet). Wintering plovers are dependent on a mosaic of habitat patches and move among these patches depending on local weather and tidal conditions. It has been hypothesized that specific wintering habitat, which includes coastal sand flats and mud flats in close proximity to large inlets or passes, may attract the largest concentrations of piping plovers because of a preferred prey base and/or because the substrate color provides protection from aerial predators due to cryptic blending camouflage color (Nicholls and Baldassarre, 1990). The migration of the piping plover is poorly understood. They begin arriving on the wintering grounds in July and continue arriving through September. In late February, piping plovers begin leaving the wintering grounds to migrate back to their breeding sites. Northward migration peaks in late March, and by late May most birds have left the wintering grounds. Vegetation imposes an extreme threat of predators on breeding adults. On the northern breeding grounds, river alteration and reservoir creation cause high water flow where birds once relied on exposed sand bars to breed. However, diversion of peak flows in northern nesting habitat is also harmful. The result is the encroachment of vegetation that is usually kept under control by scour during high river flows. This species remains in a precarious state given its low population numbers, sparse distribution, and continued threats to habitat throughout its range. About 2,299 birds were located on the U.S. wintering grounds during the 2001 census (Haig and Ferland, 2002). During the winter 2006 census, 321 birds were counted on the Gulf Coast of Florida; 29 in Alabama; 78 in Mississippi; 226 in Louisiana; and 2090 in Texas (Elliot-Smith et al., 2009). The highest numbers of wintering plovers occurred along the Texas coast (43.6%), with Louisiana ranked second (21.4%). Piping plovers were commonly found on mud flats (36.3%), sandy beaches (33.2%), and sand/salt flats (23.1%) (Haig and Ferland, 2002).

Whooping Crane

The whooping crane (*Grus americana*) is an omnivorous, wading bird. Whooping cranes currently exist in three wild populations and at five captive locations (USDOI, FWS, 1994). All of the populations are listed as endangered. The only self-sustaining wild population nests in the Northwest Territories and adjacent areas of Alberta, Canada, primarily within the boundaries of Wood Buffalo National Park. These birds winter in coastal marshes and estuarine habitats along the Gulf Coast in the Aransas National Wildlife Refuge in Texas, and they represent the majority of the world's population of free-ranging whooping cranes. Another wild flock was created with the transfer of wild whooping crane eggs from nests in the Wood Buffalo National Park to be reared by wild sandhill cranes in an effort to establish a migratory Rocky Mountains Population (USDOI, FWS, 1994). This population summers in Idaho, western Wyoming, and southwestern Montana, and it winters in the middle Rio Grande Valley, New Mexico. The third wild population is the first step in an effort to establish a nonmigratory population in Florida (USDOI, FWS, 1994). The 2007 wild populations were estimated to total 355; the captive population contained 148 birds (Stehn, personal communication, 2007).

4.1.1.14.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of the coastal and marine birds for the CPA proposed action can be found in Chapter 4.2.1.1.7 of the Multisale EIS, and any new information since publication of the Multisale EIS is presented in Chapter 4.1.9.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the routine events incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The possible effects of routine activities on coastal and marine birds of the Gulf of Mexico and contiguous waters and wetlands are discussed below. Federally listed endangered or threatened bird species are included in this discussion with nonlisted species because the potential impacts are the same or very similar. Major, potential impact-producing factors for marine birds in the offshore environment include OCS-related helicopter and service-vessel traffic and associated noise, air emissions, degradation of water quality, habitat degradation, discarded trash and debris from service-vessels and OCS structures, and structure presence and associated light and presence. Any effects on birds are especially dire for intensively managed threatened and endangered populations. For example, endangered and threatened species may be harmed by any impact on viable reproductive population size or destruction of or disturbance around key habitats.

Fidelity to coastal and marine bird nesting sites varies from year-to-year along the Gulf Coast. Site abandonment along the northern Gulf Coast has often been attributed primarily to habitat alteration and excessive human disturbance (Martin and Lester, 1991). Many of the overwintering shorebird species remain within specific areas throughout the season and exhibit among-year wintering site fidelity, at least when not disturbed by humans. These species may be especially susceptible to localized impacts, resulting in habitat loss or degradation unless they move to more favorable habitats when they are disturbed by humans.

The effects of disturbance by air or vessel traffic to birds are highly variable. Behavior patterns may be temporarily influenced (e.g., change from foraging behavior to alert behavior) or birds may be temporarily or permanently displaced. Reproductive behaviors including pair formation and courtship displays may be interrupted; breeding birds may become habituated to noise and the presence of humans (Nisbet, 2000). Aircraft may be forced to fly below legal (Federal Aviation Administration or FWS) minimum altitudes in inclement weather, possibly increasing disturbance effects on birds.

Air pollution may cause physiological impairment and further lead to diseases. Effects may vary from lethal to sublethal and from short term to long term. Nonpolar, hydrophobic pollutants become a special problem for long-distance migrant birds that rely on fat deposits for extra energy requirements. More fat will hold more of that kind of pollutant. Migrants are generally sensitive to airborne toxins because of sustained high ventilation rates required for flight. Indirect effects of air emissions include adverse synergistic effects with other stressors and shifts in food supplies. Acid deposition affects the forest forging habitat of birds. Air emissions may cause changes in bird distribution and abundance, but the emissions must be diagnostically separated from other possible factors (e.g., weather and food supplies) that could have the same effect.

The impacts of discharges into water vary from short term to long term and from sublethal to lethal. Impacts may be from ingestion or contact (direct) or from the changes in the distribution, composition, or abundance of preferred foods (indirect). Discharges may affect the breeding success of seabird nesting colonies prevalent along the shores of the northern Gulf of Mexico. Maintenance dredging and resuspension of sediment in canals and navigation channels increases turbidity over time. Birds feeding in such waters would likely experience chronic, sublethal impacts.

Habitat and plant substrates can be described as the physical environment used by a bird. Birds select their habitat at various times in their life histories according to their needs. The greatest negative impact to coastal and marine birds is the loss or degradation of preferred or critical habitat and, for a threatened or endangered species, this may result in global extinction. This discussion applies to both federally listed endangered/threatened bird species and nonlisted species, since the effects are the same or very similar. The extent of bird displacement resulting from habitat loss is highly variable among species, based upon specific habitat requirements, which for many species is poorly understood. As displaced birds move to undisturbed areas of apparently similar habitat, the presence of additional conspecifics may

exert additional pressure on the habitat, as a result of intra- and interspecific competition for space or food.

Pipeline landfalls and terminals, and other onshore OCS-related construction, can alter or destroy wetland habitat, resulting in displacement of associated avian communities. Seabird nesting colonies are particularly sensitive and should always be avoided by construction activities. Environmental regulations require replanting and restoration of wetlands destroyed by pipelaying barges and associated onshore pipeline installation. However, onshore pipelines cross a wide variety of coastal environments and can therefore affect certain species generally not associated with freshwater, marine, or estuarine systems. The northern Gulf of Mexico and areas inland from it have a large diversity of habitats for a variety of avian species including migrants and breeding and wintering birds.

Seabirds ingest plastic objects and other marine debris more frequently than do any other taxon (Ryan, 1990). Interaction with plastic materials may lead to permanent injuries and death. The effects of plastic ingestion may be long-term and may include physical deterioration due to malnutrition; plastics often cause a distention of the stomach, thus preventing its contraction and simulating a sense of satiation (Ryan, 1988). The chemical toxicity of some plastics can be high, posing a hazard in addition to obstruction and impaction of the gut (Fry et al., 1987). Some birds also feed plastic debris to their young, which could reduce fledging success and offspring survival rates. As a result of stress from the consumption of debris, individuals may weaken, facilitating infection and disease; migratory species may then not have the energetic capacity to initiate migration or complete the migration process.

Proposed Action Analysis

The transportation or exchange of supplies, materials, and personnel between coastal infrastructure and offshore oil and gas structures is accomplished with helicopters, aircraft, boats, and a variety of service vessels (**Table 3-2**). It is projected that 1,004,000-2,241,000 helicopter operations related to the CPA proposed action would occur over the life of the proposed action; this is a rate of 25,100-56,025 annual helicopter operations. Service vessels would use selected nearshore and coastal (inland) navigation waterways, or corridors, and adhere to protocol set forth by USCG for reduced vessel speeds within these inland areas. It is projected 137,000-220,000 service-vessel round trips related to the CPA proposed action would occur over the life of the proposed action; this is a rate of 3,425-5,500 service-vessels trips annually. In laboratory experiments, factors determining an animal's susceptibility to noise-induced damage, such as species, age, auditory range, and recovery process can be controlled. Memphis State University (1971) mentions "the large, well-done body of literature exploring the effects of noise upon auditory structures and hearing."

Animals exposed intermittently to noise had less impact than animals exposed continuously (Memphis State University, 1971). The extent of noise-induced impacts depends on the intensity, frequency spectrum, duration, pattern of exposure, and individual susceptibility. Noise-induced stress may have increased impacts if combined with other stress. Memphis State University (1971) implies that studies of relatively less intense noise pollution such as that from helicopters and service vessels are few.

Disturbances from OCS-related helicopter or service-vessel traffic to coastal birds can result from the mechanical noise or physical presence (or wake) of the vehicle. This discussion applies to both federally listed endangered/threatened bird species and nonlisted species since the effects are the same or very similar.

The Federal Aviation Administration and corporate helicopter policy advise helicopters to maintain a minimum altitude of 700 ft (213 m) while in transit offshore and 500 ft (152 m) while working between platforms. When flying over land, the specified minimum altitude is 1,000 ft (305 m) over unpopulated areas or across coastlines and 2,000 ft (610 m) over populated areas and biologically sensitive areas such as wildlife refuges and national parks. Many undisturbed coastal areas and refuges provide preferred and/ critical habitat for feeding, resting (or staging), and nesting birds.

Flushing from the nest is the only behavioral response in raptors that is known to be correlated with severe impact from helicopter overflights (Awbrey and Bowles, 1990). Flushing may exert its influence by having eggs and young kicked out of a nest, exposed to predators, and exposed to potential negative effects of cold or heat stress (inclement weather). Important raptors include the bald eagle and peregrine falcon, recently both federally delisted as endangered or threatened species. These species may exhibit impacts from helicopters similar to other raptors previously studied.

A synthesis of literature on impacts of helicopter and other aircraft overflights on raptors by Awbrey and Bowles (1990) is presented as follows (with additional information from Frid and Dill, 2002).

Sometimes flushing, alertness, and other antipredator responses to nonlethal stimuli should become stronger with repeated exposure to the stimuli (Frid and Dill, 2002). This conclusion is especially important because studies on human disturbance of birds sometimes incorrectly state or imply that birds always become accommodated to noise. Sensitization sometimes occurs instead. For example, loom rate is the rate at which a predator or human disturbance proxy for a predator increases in size as it approaches; loom rate is higher for nearby predators than for distant predators. As multiple exposures to the stimuli at different distances occur, the bird should increase its flight initiation distance to stimuli with higher loom rates because as the bird will associate the high rate with closeness of the predator, becoming sensitized rather than habituated because the bird learns to recognize this high-loom-rate cue to danger of close predator approach (Frid and Dill, 2002).

Flushing has a higher probability early in the breeding season. The cause of this increased likelihood is perhaps later habituation. Another potential cause is increased attention to nesting as the breeding season proceeds. This increase in parental attentiveness with time could result because as this season progresses, renesting success declines and the cost of parental investment in a first nest increases. The bald eagle and peregrine falcon, cliff and tree nesting raptors, often experience low levels of egg predation, probably less than ground-nesting raptors; flushing may be relatively less important for these two species. “Nonspecific” stimuli, where the bird does not identify (specify) the disturbing stimulus as a human (when the disturbing agent was a car or an aircraft, for example), drive raptors away from feeding areas only briefly

Birds can lose eggs and young when predators attack nests after parents are flushed into flight by service-vessel noise. Overall breeding success (ratio of fledged birds per nest to hatched birds per nest) may be reduced. Chronic effects on breeding are especially serious for endangered or threatened species because subsequent recovery may not be possible or may be delayed. Routine presence and low speeds of service vessels within inland and coastal waterways would possibly reduce the effects of disturbance from service vessels on nearshore and inland populations of coastal and marine birds.

Contamination of wildlife by air emissions can occur in three ways: inhalation, absorption, and ingestion. Inhalation is the most common mode of contamination for birds (Newman, 1980). Levels of sulfur oxide (mainly SO_2) emissions from hydrocarbon combustion from OCS-related activities are of concern in relation to birds.

The indirect effects of air emissions on wildlife include food web contamination and habitat degradation, as well as adverse synergistic effects of air emissions with natural and other manmade stresses. Air pollutants may cause a change in the distribution of certain bird species (e.g., Newman, 1977; Llacuna et al., 1993).

Chapter 4.1.1.1.2 provides an analysis of the routine effects of the proposed action on air quality. Emissions of pollutants into the atmosphere from the activities associated with the proposed action would have minimum effects on offshore and onshore air quality because of the prevailing atmospheric conditions, emission heights and rates, and pollutant concentrations. The NAAQS concentrations are far below concentrations that could harm coastal and marine birds. The most likely pathway for air pollution to affect birds is through acidification of inland waterbodies and soils, and a subsequent change in trophic structure (Environmental Science & Research, 1998).

Chapters 4.1.1.2.1.2 and 4.1.1.2.2.2 provides an analysis of the effects of the CPA proposed action on water quality. This discussion applies to both federally listed endangered/threatened bird species and nonlisted species since the effects are the same or very similar. Expected degradation of coastal and estuarine water quality resulting from of OCS-related discharges may affect coastal birds directly by means of acute or chronic toxic effects from ingestion or contact, or indirectly through the contamination of food sources or habitat loss/degradation. Operational discharges or runoff in the offshore environment could also affect seabirds (e.g., laughing gulls) that remain and feed in the vicinity of offshore OCS structures and platforms. These impacts could also be both direct and indirect. Many seabirds feed and nest in the Gulf; therefore, water quality may also affect breeding success (measured as the ratio of fledged birds per nest to hatched birds per nest). Produced water is an operational discharge containing hydrocarbons, trace heavy metals, radionuclides, sulfates, treatment chemicals, and produced solids that represents most of the waste discharged from offshore oil extraction production facilities (Fraser et al., 2006). The relationship between produced-water discharge and oil sheens is not well understood. In cold

waters, oiled birds (especially divers) lose insulation and may die from hypothermia (Fraser et al., 2006); even contact with thin sheens have the potential to reduce water repellency and insulative characteristics of feathers (O'Hara and Morandin, 2010; see also Stephenson, 1997). The maximum allowable hydrocarbon concentration in the U.S. is an average of 29 mg/L per month for the OCS and specifies a maximum (daily average) of 42mg/L daily; events that may cause sheens (USEPA, 2004, in Fraser et al., 2006, p. 149). Assertions that the dilution potential of the ocean as a receiving environment makes ocean discharge an effective waste treatment for produced water have no supporting evidence. Field evidence that any contact between a bird and oil or oily water will be lethal without rehabilitation is also lacking (Fraser et al., 2006). The null hypothesis that produced water and resulting sheens do not kill birds needs to be tested (Fraser et al., 2006).

The analysis of the potential impacts to coastal environments (**Chapter 4.1.1.3.2**) concludes that the CPA proposed action is not expected to adversely alter barrier beach configurations significantly beyond existing, ongoing impacts in very localized areas downdrift of artificially jettied and maintained channels. Adverse impacts of pipeline and navigation canals are the most significant OCS-related and proposed-action-related impacts to wetlands that may be used by many species of birds. Initial impacts are locally significant and largely limited to where OCS-related canals and channels pass through wetlands. For the CPA proposed action, 0-1 new pipeline landfalls (Chapter 4.1.2.1.7 of the Multisale EIS) and 0-1 new gas processing plants (Chapter 4.1.2.1.4.2 of the Multisale EIS) are projected.

Coastal and marine birds are susceptible to entanglement in floating, submerged, and beached marine debris; specifically in plastics discarded from both offshore sources and land-derived litter and waste disposal (Heneman and the Center for Environmental Education, 1988). This discussion applies to both federally listed endangered/threatened bird species and nonlisted species since the effects are the same or very similar. It is expected that coastal and marine birds would seldom become entangled in or ingest OCS-related trash and debris as a result of BOEMRE prohibitions on the disposal of equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL, Annex V, Public Law 100-220 (101 Statute 1458), which prohibits the disposal of any plastics, garbage, and other solid wastes at sea or in coastal waters, went into effect January 1, 1989, and is enforced by USCG.

Each spring, migratory land birds, including neotropical passerines that cannot feed at the water surface or rest there, cross the Gulf of Mexico from wintering grounds in Latin America to breeding grounds north of the Gulf of Mexico. Some birds use offshore platforms as stopover sites for this migration; this may enhance fitness. However, the quantity of natural selection against weak or sick birds may be reduced, decreasing the overall vitality of the populations. This discussion applies to both federally listed endangered/threatened bird species and nonlisted species since the effects are the same or very similar.

Migrants sometimes arrive at certain platforms shortly after nightfall or later and proceed to circle those platforms (the phenomenon is called a nocturnal circulation event) for variable periods ranging from minutes to hours. Russell (2005) notes that, "because of the anecdotal nature of our circulation observations, we are reluctant even to speculate about the average duration of participation in circulation or the typical energetic consequences of participating in these events." On the other hand, Weir (1976) states "nocturnal kills are virtually certain wherever a lit obstacle extends into an air space where birds are flying. The magnitude of the kill would be determined by the time of year, location, height, light and cross-sectional areas of the obstacle and weather conditions." Circulations increase the risks for birds to collide with platform structures and with each other. Large attractions to lights and collision mortalities are mostly during overcast nights with drizzle and fog. The attractive effect of lights during cloudy nights is enhanced by fog, haze, or drizzle when moisture droplets in the air refract the light and greatly increase the illuminated area (Wiese et al., 2001). Starving, exhausted, circulating birds may land on the platforms. Birds that dropped out of nocturnal circulations sometimes became trapped in well-lit interior areas of platforms, and these birds appeared sublethally stressed (Russell, 2005). However, a total of 140 birds on the nine platforms were recorded as dead because of starvation for the entire spring of 2000 study period (Russell, 2005). More detail is presented in Chapter 4.2.1.1.7 of the Multisale EIS. It is projected that 32-44 production structures are projected to be installed as a result of the CPA proposed action (**Table 3-2**). Nocturnal circulation on these platforms is assumed to have minimal and mostly sublethal impacts on migrating bird populations. This conclusion results from the confirmed low mortality from starvation for all birds that landed on the platforms examined by Russell (2005) and from the suggested

sublethal stress in birds that dropped out of circulation. The presence of a drilling rig may attract seabird prey (invertebrates and/or fish) to a site, causing an increase in seabird abundance there relative to bird density away from the rig or at the rig during pre-spudding (Baird, 1990). The discharge of human waste from a rig may fertilize the area, leading to increases in seabird prey (Wiese et al., 2001). For some seabirds, such as shearwaters, offshore oil platforms have become sites where otherwise patchy or scarce prey are more predictable and concentrated (Wiese et al., 2001). Storm-petrels and other procellariiforms forage at night on vertically migrating bioluminescent prey and are naturally attracted to any kind of light. Storm-petrels often fly directly into lights and flares, resulting in death or injury by impact or burning (Wiese et al., 2001).

Summary and Conclusion

The majority of effects resulting from routine activities with the CPA proposed action on endangered/ and nonendangered/threatened coastal and marine birds are expected to be sublethal. These effects include behavioral effects, exposure to or intake of OCS-related contaminants or discarded debris, temporary disturbances, and displacement of localized groups from impacted habitats. Chronic sublethal stress, however, is often undetectable in birds. As a result of stress, individuals may weaken, facilitating infection and disease; migratory species may then not have the energetic reserves necessary to complete their migration. Nocturnal circulation around platforms may create acute sublethal stress from energy loss and increase the risks of collision, while stopovers on platforms would reduce energy loss. Because of regulatory standards for air and water quality, as discussed in **Chapters 4.1.1.1, 4.1.1.2.1, and 4.1.1.2.2**, emissions or produced waters should have a small effect on birds. No significant habitat impacts are expected to occur directly from routine activities resulting from the CPA proposed action because of the distance of these activities from shore. Secondary impacts from pipeline and navigation canals to coastal habitats would occur over the long term and may ultimately displace species. These activities would occur whether the proposed action was implemented or not; therefore, the proposed action itself would not increase these secondary impacts to birds.

4.1.1.14.3. Impacts of Accidental Events

A detailed impact analysis of the coastal and marine birds for the CPA proposed action can be found in Chapter 4.4.8 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.9.3 of the 2009-2012 Supplemental EIS.

The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Background/Introduction

This chapter discusses impacts to coastal and marine birds resulting from the CPA proposed action. Impact-producing factors include oil spills and oil-spill cleanup. Impact discussions are combined for threatened/endangered birds and nonthreatened/nonendangered birds because impacts of oil spills are potentially similar for both.

Oil spills represent the greatest potential direct and indirect impact to coastal and marine bird populations. Birds that are heavily oiled succumb to acute toxicity effects shortly after exposure (Clark, 1984; Leighton, 1993).

If the physical oiling of individuals or local groups of birds occurs, some degree of both acute and chronic physiological stress associated with direct and secondary uptake of oil would be expected.

The symptoms of oiling are plentiful but are all important because, while resilient or rehabilitated birds may quickly recover, symptoms occurring in many birds may cause reduction or loss of whole populations. Symptoms of contact with the persistent fraction of crude oil may be the most important because that fraction usually has the fate of contacting shallow waters and shorelines and being incorporated into wetland sediments. Small coastal spills, pipeline spills, and spills from accidents in navigable waterways can contact and affect the different groups of coastal and marine birds, most commonly seabirds, divers, marsh and wading birds, waterfowl, and some species of shorebirds. Lightly

oiled birds can sustain tissue and organ damage from oil ingested during feeding and grooming or from oil that is inhaled. Birds that are heavily oiled are usually killed. Lighter PAH's like naphthalene and phenanthrene are volatile and water-soluble, but they are somewhat more persistent compared with lighter, more volatile, and more water-soluble hydrocarbons like benzene. They have the greatest impacts on birds because of their persistence and high concentration. They are harmful to cell membranes (White and Baker, 1999), including the highly specialized membranes of nerve cells (Hell and Ehlers, 2008; Byrne and Roberts, 2009) that must function properly for vital behavior to remain adaptive. Thus, low levels of oil could deleteriously affect behavior and therefore could interfere with food detection, feeding impulses, adaptive changes in food preferences and the ability to discriminate between poor versus ideal food sources and ideal sources, predator avoidance, definition and defense of breeding and feeding territories, recognition of family members, and homing of migratory and philopatric species. The toxicity profile for alkylated naphthalene and phenanthrene in birds has been insufficiently characterized (Klasing et al., 2007). Naphthalene fed to birds resulted in reduced food consumption, reduced growth rate, and six physiological disorders (Klasing et al., 2007). Naphthalene had no impact on several reproductive traits, internal organs, and 12 blood parameters (Klasing et al., 2007). Systemic inflammation did not happen. For chicks hatched from eggs of Japanese quail hens that had ingested naphthalene, growth rate, mortality, and two blood parameters were unaffected (Klasing et al., 2007).

The mandatory use of waterbird feeding areas at the sea surface and intertidal wetland zone, where spilled oil tends to accumulate, makes the birds vulnerable to exposure to oil. Wetland sediments have low oxygen diffusion rates and are waterlogged and therefore not aerated with oxygen-rich air; hence, they have low redox potential (Mitsch and Gosselink, 2007). Oxygen has a very low rate of diffusion from the atmosphere through pore water in waterlogged sediment. Oil also diffuses very slowly through pore waters to reach the sediment-water interface. Therefore, when oil gets into vegetated or unvegetated sediment, low redox potentials (from reduced oxygen availability and oxygen loss through bacterial respiration) and absence of light may result in oil that can neither be oxidized by bacteria and sunlight nor reach the sediment-water interface and evaporate. The oil may also remain in its unweathered toxic state indefinitely. However, weathering-related effects on the oil on its the path to the coast ameliorates, to some extent, toxicity at the shoreline. If physical oiling of individuals or local groups of birds occurs, some degree of both acute and chronic physiological stress associated with direct and secondary uptake of oil would be expected. Affected individual birds may initially appear healthy at first, but they may be affected by physiological stress that does not occur until much later. Biochemical impacts of lighter PAH's have not been extensively described, but they could possibly include increased susceptibility to physiological disorders including all sorts of disruption of homeostasis, weakened immune systems and reduced resistance to disease, and disruption of respiratory functions (Nelson and Cox, 2008; Briggs et al., 1996). The internal biochemical environment of the bird has a large number of components, interactions, and functions (Nelson and Cox, 2008) that may provide potential points of attack from petrochemicals. The network and feedback system nature of the internal environment (Nelson and Cox, 2008) also provides routes by which an effect on one process can lead to cascading sublethal, chronic effects and a myriad of interconnected problems.

Under natural conditions, water does not penetrate through the vanes of the feathers because air is present in the tiny pores in the lattice structure of the feather vane. Birds swimming in dispersant had reduced buoyancy and water penetration through the feathers. Dispersants reduce water surface tension in the feather lattice pores (they have a surfactant component) and render them water attracting instead of water repelling (Stephenson, 1997; Stephenson and Andrews, 1997). Beginning at a certain surface tension, water will penetrate the pores of the feathers, and death from reduced thermoregulatory function hypothermia may result (Lambert et al., 1982; Stephenson, 1997; Stephenson and Andrews, 1997). Dispersants alone cause water penetration of the feathers (Lambert et al., 1982) by reducing the surface tension of the water in the pores of the lattice. A much smaller minimum volume (1/100) of oil treated with Finasol OSR-5 dispersant, relative to the volume of untreated oil, was required to produce a substantial effect on plumage insulation and thermoregulation in eiders (Jenssen, 1994). Even with a healthy, water-repellant plumage, waterfowl and seabirds living at medium to high altitudes will, for most of the year, require an augmented resting metabolic rate when floating on the water surface, due to the water's relatively high heat conductance and water pressure on the feathers provided by the buoyant force on the bird (Stephenson, 1997). In other words, even unoiled feathers do not provide complete insulation against cold.

Ingestion of oil by birds may affect reproductive ability, cause anemia, result in reduced eggshell thickness that promotes cracking under the weight of an incubating parent, and cause four physiological disorders (Fry et al., 1986; Butler et al., 1988; Velando et al., 2005a and 2005b; Zuberogoitia et al., 2006; Zabala et al., 2010; Szaro et al., 1978a and 1978b; Lambert et al., 1982; Rocke et al., 1984; Leighton, 1993; Fowler et al., 1995; Alonso-Alvarez et al., 2007a; Perez et al., 2010).

External oiling of eggs may slow embryonic growth, induce tumor growth, reduce gas conductance through the eggshell, and decrease hatchability (Jenssen, 1994). Impacts on vital life history characteristics such as growth rates (Szaro et al., 1978a and 1978b; Trivelpiece et al., 1984) or reproductive parameters such as reproductive success may occur, resulting in possible local population extinction. Indirect effects occur by fouling of the nesting habitat and displacement of individuals, breeding pairs, or populations to less favorable habitats (e.g., Velando et al., 2005b). Competition may exclude refugee seabirds from all habitats, especially for seabird colonies in southeastern Louisiana.

A mathematical model by Peakall et al. (1989) showed that exposure to a slick at the surface (which would usually reduce in size or vanish in response to chemical dispersants) was the sensitive pathway to contamination in seabirds. Exposure to oil in the water column (a primary destination of chemically dispersed oil from surface slicks, along with the seafloor) was modeled to be minor. Sometimes, because of lack of thorough training of all personnel or the sheer scale of operations, the air, vehicle, and foot traffic that takes place during shoreline cleanup may disturb nesting populations and degrade or destroy habitat.

New research, experience, and testing will help the efficacy of the rehabilitation of oiled birds and will probably improve scare methods that will keep birds away from an oil slick. Rehabilitation can be significant to the survival of threatened and endangered bird species. Chemically dispersed oil has sublethal biochemical and physiological toxicity to seabirds similar to that of oil alone (Peakall et al., 1987). Toxic effects of untreated and chemically dispersed oil on the hatching success of waterfowl and seabirds were similar (NRC, 1989).

Preening of oiled plumage may drive oil deep into plumage (Jenssen, 1994; Jenssen and Ekker, 1991). Birds that must feed on or in the water lose heat faster than semiaquatic birds that can feed with a dry plumage on land (Jenssen, 1994). Some aquatic birds such as cormorants, when oiled, must either starve on land or enter the sea where hypothermia will kill them (Jenssen, 1994).

Residual material that remains after evaporation and solubilization is water-in-oil emulsions (mousse), which are the primary pollutant onshore after offshore spills. The mixing of mousse and sediments form aggregates that have the odor of oil and, after photo- and biological oxidation, form asphaltic "tarballs" and pavements (Briggs et al, 1996). Mousse emulsions may be the most toxic petroleum component because they are the most hydrophobic and will penetrate the hydrophobic core of the plasma membrane of cells and will cause disruption of the membrane and enter the cells as well (Briggs et al., 1996). Common symptoms of exposed birds include dehydration, gastrointestinal problems, infections, arthritis, pneumonia, hemolytic anemias, cloacal impaction, and eye irritation. Therefore, antibiotic treatments, nutritional support, rehydration, and other protocols are used at rehabilitation centers (Briggs et al., 1996). Capture-recapture methods to calculate survival after rehabilitation may work better for waterfowl than for seabirds (Dunne and Miller, 2007). Capture-recapture data for the 30-year period 1974-2004 and for the 11-year period 1993-2004 demonstrated that oiling and subsequent rehabilitation do not have an effect on post-release survival in mallards (Dunne and Miller, 2007). In the same study, for Canada geese, data from an unfavorable, aberrant release site were excluded and oiling and rehabilitation had no effect on post-release survival (Dunne and Miller, 2097). Rehabilitation may even give a higher probability of survival to Canada geese than unoiled controls because rehabilitation provides consistent access to food, a brief protection from predators, and general health management practices (Dunne and Miller, 2007). Standard blood parameters of birds brought to rehabilitation centers were first measured in the mid-1970's. About 12 parameters, including effects on both red and white blood cells, have been involved (Briggs et al., 1996). The metabolic rate, correlated with heat loss, was not substantially increased by chemically dispersed oil relative to the increase caused by oil alone (Lambert et al., 1982). Oiled birds spend more time preening off the water, exposing them to predation and reducing the time available for feeding, breeding, and other activities (Stephenson and Andrews, 1997). Some body cells respond to oil with excessive deposition of a yellow-brown pigment, hemosiderin, causing hemosiderosis (Briggs et al., 1996). Impacts of oil on the immune system include inflammation of the gastrointestinal tract following oil ingestion, which affects the intestinal mucosa

lining. The mucosa functions in immune defense and in suppression of immune response to certain antigens such as those in foods.

Mallards exposed to cold temperature stress had increased mortality rates if they were fed with oil, which caused seriously increased stress from release of corticosteroid stress hormone caused by the oil (Briggs et al., 1996).

The immune system has a large number of components, interactions, and functions that can provide potential targets for petrochemicals. The network nature of the system also provided a pathway by which an effect on one component can lead to a myriad of other interconnected problems (Briggs et al., 1996). These authors note, "A complete understanding of how the immune system works, including a finished roster of its components, is far from achieved."

A search was conducted for new information published since completion of the Multisale EIS. A search of Internet bibliographic databases, as well as personal interviews with authors of references used in the Multisale EIS, was conducted to determine the availability of recent information since publication of the Multisale EIS. The Internet databases examined included Google Advanced Book Search, Google Advanced Scholar Search, and Gale Databases. Authors were contacted and interviewed to investigate any recent published data that may be available.

A literature search found Burger (1997), who reports that exposure to small amounts of oil may weaken birds or decrease their body weight so they may go for years without problems until they face a severe environmental stress. Then, they have a higher mortality than unexposed birds. Burger (1993) notes that spill volume has little or no correlation with bird mortality. Similarly, Camphuysen et al. (2005) found that, for six major spills in Western Europe, spill volume (ranging from 170 tonnes of heavy fuel for the *Tricolor* to 223,000 tonnes of crude for the *Amoco Cadiz*) was not correlated with estimated bird mortality (ranging from about 5,000 birds for the *Braer* to about 200,000-300,000 birds for the *Stylis*). In a comparison study with similar results (Kingston, 1995), the *Braer* spilled 85,000 tonnes but killed only about 4,000 birds, while the *Exxon Valdez* spilled only 35,000 tonnes but killed about 100,000-300,000 birds. The state of the seas at the time of the *Exxon Valdez* accident was calm and the oil was heavy, high-viscosity crude, resulting in little capability for chemical or natural dispersal. In comparison, the *Braer* oil was light crude and seas were heavy, creating a large potential for dispersal. Because of its undispersed state, the *Exxon Valdez* oil principally affected surface-dwelling and shore-dwelling organisms such as birds. The *Braer* oil did not even moderately affect shores, and because of the dispersed state of the oil, it affected only sea bed and pelagic water column biota and killed very few birds. However, Wilhelm et al. (2007) shows that the lack of correlation of bird mortality with spill volume no longer holds when spill volume is scaled as the perimeter of the oil slick by putting a fractional exponent on spill volume (see also Tan et al., 2010). An estimated 10,000 seabirds were killed in a 1,000-bbl spill from the FPSO *Terra Nova* vessel off the Grand Banks of Newfoundland on November 21, 2002. No birds could be counted on the beach because winds blew out to sea, and no seabird data were available from before the spill. Even so, birds inside and outside the slick area were counted from a ship at sea while the slick was on the water. The density of seabirds in the affected area, timing (i.e., if peak periods in bird density overlap temporally with the spill), wind conditions, wave action, and distance to the shore may have more effect than spill volume (Castege et al., 2007; Byrd et al., 2009). Long-term impacts of the *Sea Empress* spill (72,000 tonnes of crude) in Wales were moderate; in a 10-year study (Moore, 2006), the numbers of the majority of affected breeding seabird colonies (primarily alcids) recovered to pre-spill values within 2-3 years. Localized effects on the distribution of migratory wetland birds were not evident after 2 years. Khan and Ryan (1991) note substantial mortality in seabirds after attempts at rehabilitation (see also Anderson et al., 1996; Sharp, 1996). Sublethal symptoms of contamination were numerous and substantial prior to the mortality. Similarly, numerous symptoms were found in dead birds on the shore and in birds dying after rehabilitation; these birds were affected by the *Prestige* oil spill off the coast of Spain on November 19, 2002 (Camphuysen et al., 2002; Balseiro et al., 2005; Velando et al., 2005a; Zuberogoitia et al., 2006; Perez et al., 2008; Zabala et al., 2010). Final major impacts to European shags (*Phalacrocorax aristotelis*) from the *Prestige* spill probably came in 2003 from a decimated food supply of fish (Velando et al., 2005b). As oil weathered, the exposure of seabirds to oil from the *Exxon Valdez* spill shifted from direct oiling to ingestion with food (Hartung, 1995).

Alonso-Alvarez et al. (2007a and 2007b) used blood chemistry of yellow-legged gulls (*Larus michahellis*) to compare long-term sublethal toxicity of the *Prestige* oil spill with short-term experimental sublethal toxicity in captive birds fed small amounts of fuel oil. Long-term effects were measured about

19 months after the spill. Short-term effects were measured in captive birds fed a small amount of fuel oil for 7 days. Adults from oiled colonies and fuel-oil-fed experimental birds had higher total PAH's and lower levels of three natural metabolites. Calcium was lower in oil-fed females than in control females, but it was the same in oil-fed and control males. Calcium is important for sufficient egg shell thickness in breeding females.

Parsons (1994) provides the following unique before and after data for impacts of a spill on birds. Extensive shoreline and salt marsh were oiled by a January 1990 Exxon spill in the Arthur Kill and Kill van Kull estuaries of New York Harbor. Double-crested cormorants had reached their pre-spill population growth by 1991. Productivity of herring gulls remained unchanged by the spill. Most heron populations increased after the spill. Great black-backed gulls had a loss of abundance. Snowy egrets and glossy ibis used salt marsh and mud flat habitat, some of which was oiled. Black-crowned night heron and glossy ibis had delayed nesting after the spill and, along with snowy egret, showed lower reproductive success after the spill. Egg laying and hatching were generally more successful than chick-rearing because of the shortage of food fed to the chicks. Waterfowl were not affected seriously, except for a short-term decline in mallards.

The new information does not conflict with information in the Multisale EIS and the 2009-2012 Supplemental EIS, and often it is similar to or supports the information in these two documents.

Proposed Action Analysis

The probabilities of oil spills occurring and contacting coastal bird habitat within 10 days as the result of the proposed action over its 40-year life are 7-11 percent for the threatened piping plover; 1 percent for the endangered whooping crane; 8-13 percent for the brown pelican; 8-13 percent for raptors; 8-14 percent for gulls, terns, and charadriid allies; 8-14 percent for shoreline charadriids; 8-13 percent for diving birds; 8-14 percent for wading birds; and 9-14 percent for waterfowl. All of these groups, except for the whooping crane, are widely distributed across the Gulf (Figures 4-22 through 4-31 of the Multisale EIS); therefore, an oil spill would only affect a small portion of a bird group. The combined probabilities are always <15 percent. Small coastal spills, pipeline spills, and spills from accidents in navigable waterways can contact and affect the different groups of coastal and marine birds, most commonly marsh birds, waders, waterfowl, and certain shorebirds. In the CPA, an estimated total of 46-102 coastal spills would occur over a 40-year production period. Impacts on seabirds at sea are not part of the analysis and their seasonal distribution needs to be characterized. Many species breed outside the United States, sometimes outside the Northern Hemisphere. Impacts of the CPA proposed action on all coastal birds are expected to be negligible. Oil-spill cleanup is not expected to affect coastal birds if all personnel are completely trained.

The DWH event and resulting oil spill in Mississippi Canyon Block 252 and the related spill-response activities may impact birds that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected coastal and marine bird environment. For the latest available information on oiled or affected birds documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c). **Figure 4-14** and **Tables 4-5 and 4-6** summarize birds collected by date; this information was obtained from FWS as part of the NRDA process. **Table 4-4** compares past oil spills and relative impacts to birds.

Summary and Conclusion

Oil spills have the greatest impact on coastal and marine birds. Small amounts of oil can affect birds, and mortality from oil spills is often related to numerous symptoms of toxicity. Data from actual spills strongly suggest that impacts on their food supply are delayed after initial impacts from direct oiling. Mechanisms of toxic oil effects other than direct oiling of plumage have seldom been confirmed. Oil-spill impacts on birds from the CPA proposed action are expected to be negligible because an oil spill would only affect a small portion of a bird group. Impacts of oil-spill cleanup from the proposed action are also expected to be negligible.

4.1.1.14.4. Cumulative Impacts

A detailed impact analysis of the coastal and marine birds for the CPA proposed action can be found in Chapter 4.5.8 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.9.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Background/Introduction

This cumulative analysis considers impact-producing factors that may adversely affect populations of nonendangered/nonthreatened and endangered/threatened birds related to OCS and non-OCS activities. Both listed and nonlisted birds are discussed together because the impacts are similar.

The OCS activities include the following:

- the proposed action; and
- prior and future OCS sales.

Non-OCS activities include the following:

- State oil and gas activity;
- crude oil imports by tankers; and
- other commercial, military, and recreational offshore and coastal activities.

The OCS-related, impact-producing factors include the following:

- air emissions;
- degradation of water quality;
- platform and pipeline oil spills and any improperly directed spill-response activities;
- structure presence and lights;
- aircraft and vessel traffic and associated noise, including OCS helicopter and service-vessels;
- habitat loss and modification resulting from coastal facility construction and development;
- OCS pipeline landfalls; and
- trash and debris.

The non-OCS, impact-producing factors include the following:

- air emissions;
- pollution of coastal waters resulting from municipal, industrial, and agricultural runoff and discharge;
- tanker oil spills and spills related to oil and gas activities in State coastal waters and any improperly directed spill-response activities;
- aircraft and military activities including jet training overflights and sonic booms;

- nonconsumptive recreation including bird-watching activities;
- maintenance and use of navigation waterways ;
- collisions of coastal and marine birds with wind turbines, communication towers, lighted structures, tall buildings, windows, power lines, and fences;
- disease;
- storms and floods ;
- coastal development; and
- fisheries interactions (negative impacts of decreased food resources by fisheries catch and incidental seabird bycatch, and positive impacts of increased food resources from discarded bycatch).

Proposed Action Analysis

OCS-Related Impacts

Air Emissions

Air emissions include the amount of sulfur dioxide expected to be released due to the proposed action, as well as from prior and future OCS sales, and State oil and gas activity. These emissions may adversely affect coastal and marine birds. Pollutant emissions into the atmosphere from the activities under the cumulative analysis are projected to have minimum effects on offshore air quality because of the prevailing atmospheric conditions, emission heights, and pollutant concentrations. Onshore impact on air quality from emissions under the OCS cumulative analysis is estimated to be within both Class I and Class II PSD allowable increments as applied to the respective subareas. Emissions of pollutants into the atmosphere under the cumulative analysis are projected to have little effect on onshore air quality because of the atmospheric regime, the emission rates, and the distance of these emissions from the coastline. These judgments are based on average steady state conditions and the dispersion equation for concentration estimates; however, there would be days of low mixing heights and wind speeds that could further decrease air quality. These conditions are characterized by fog formation, which in the Gulf averages about 30-40 days a year, mostly during winter. Impacts from offshore sources are reduced in winter because the frequency of onshore winds decreases and the removal of pollutants by rain increases. The summer is more conducive to air quality effects as onshore winds occur more frequently. Increases in onshore annual average concentrations of NO_x, SO_x, and PM_{10} under the cumulative analysis are estimated to be less than Class I and Class II PSD allowable increments for the respective subareas per both the steady state and plume dispersion analyses, and they are below concentrations that could harm coastal and marine birds. Indirect impacts on coastal and marine birds due to air quality under the cumulative analysis will have a negligible effect on coastal and marine birds.

Degradation of Water Quality

Water quality of coastal environments would be affected by bilge water from service vessels and point- and nonpoint-source discharges from supporting infrastructure. Water quality in marine waters would be impacted by the discharges from drilling, production, and platform removal operation operations. Degradation of coastal and inshore water quality resulting from factors related to the proposed action plus those related to prior and future OCS sales; crude oil imports by tanker; and other commercial, military, and recreational offshore and coastal activities is expected to impact coastal and marine birds.

Platform and Pipeline Oil Spills and Any Improperly Directed Spill-Response Activities

Oil spills have the greatest potential to impact coastal and marine birds. Mandatory use of waterbird feeding areas at the sea surface and intertidal wetland zone, where spilled oil tends to accumulate, makes the birds extremely vulnerable to exposure to oil. Exposure to small amounts of oil may have a latent

impact on birds and a delayed impact on their food supply. Mortality from oil spills is often related to numerous symptoms of toxicity. Oil-spill impacts on birds from the CPA proposed action are expected to be negligible. For coastal spills ≥1,000 bbl, the estimated total number of spills is 1 per 6 years from the total of OCS sources; for offshore spills ≥1,000 bbl, the estimated total number of spills for OCS sources is ≤1 per year for facilities and 1 per year for pipelines (Chapter 3.2.1 of the 2009-2012 Supplemental EIS).

Structure Lights and Presence

Every spring, migratory land birds, including neotropical passerines, cross the Gulf of Mexico from wintering grounds in Latin America to breeding grounds north of the Gulf of Mexico. Migrants sometimes arrive at certain platforms shortly after night fall or later and proceed to circle those platforms (the phenomenon is called a nocturnal circulation event) for variable periods ranging from minutes to hours. Nocturnal circulation around platforms may create lethal effects from birds colliding with platforms. Acute sublethal stress from energy loss may increase the risks of collision, while stopovers on platforms could reduce energy loss.

Aircraft and Vessel Traffic and Noise from Helicopters and Service Vessels

Helicopter and service-vessel traffic related to OCS activities could sporadically disturb feeding, resting, or nesting behavior of birds or cause abandonment of preferred habitat. The Federal Aviation Administration (Advisory Circular 91-36C) and corporate helicopter policy states that helicopters must maintain a minimum altitude of 700 ft (213 m) while in transit offshore and 500 ft (152 m) while working between platforms. When flying over land, the specified minimum altitude is 1,000 ft (305 m) over unpopulated areas or across coastlines and 2,000 ft (610 m) over populated areas and biologically sensitive areas such as wildlife refuges and national parks. The net effect of OCS-related flights on coastal and marine birds is expected to result in sporadic disturbances, which may result in displacement of localized groups. During nesting periods, this could ultimately result in some reproductive failure from nest abandonment or predation on eggs and young when a parent is flushed from a nest.

Service vessels would use selected nearshore and coastal (inland) navigation waterways and would adhere to protocol set forth by USCG for reduced vessel speeds within these inland areas. Routine presence and low speeds of service vessels within these waterways diminish the effects of disturbance from service vessels on nearshore and inland populations of coastal and marine birds. It is expected that service-vessel traffic would seldom disturb populations of coastal and marine birds existing within these areas. Recreational vessel traffic is a much greater source of impact to birds in coastal habitats. These vessels are, in most cases, required to comply with strict speed/wake restrictions (small recreational fishing boats, ski boats, etc.) but often flush coastal and marine birds from feeding, resting, and nesting areas. Such disturbances displace local groups from these preferred habitats and could lead to abandonment of the areas in general or reproductive failure. Disturbance may result in increased energy expenditures due to avoidance flights and decreased energy intake due to interference with feeding activity. It is estimated that the effects of non-OCS vessel traffic on birds within coastal areas are substantial.

In laboratory experiments, factors determining an animal's susceptibility to noise-induced damage, such as species, age, audibility range, and recovery process, can be controlled. Memphis State University (1971) mentions "the large, well-done body of literature exploring the effects of noise upon auditory structures and hearing." Hearing loss or damage to the auditory system from noise has been reported in laboratory mammals (Memphis State University, 1971).

Habitat Loss and Modification Resulting from Coastal Facility Construction and Development

Under the cumulative activities scenario, factors contributing to coastal landloss or modification include construction of 0-1 gas processing plants, as well as other facilities. The contribution of development from urban and other industrial growth would be substantial, causing both the permanent loss of lands and increased levels of disturbance associated with new construction and facilities.

Pipeline Landfalls

Under the cumulative activities scenario, factors contributing to coastal landloss or modification include construction of 32-47 OCS-related pipeline landfalls, resulting in 64-94 km (40-58 mi) of onshore pipeline. Adverse impacts of pipeline canals are the most significant OCS-related and proposed-action-related impacts to wetlands. Initial impacts are locally significant and largely limited to where OCS-related canals pass through wetlands. Pipeline canal dredging will occur in wetland bird habitat, and without mitigation, wetland habitat could be destroyed. The regulatory apparatus for mitigation of pipeline canal dredging in wetlands is managed by the U.S. Army Corps of Engineers. Mitigation would probably result in no substantial impact on wetland bird populations.

Trash and Debris

Coastal and marine birds would likely experience chronic physiological stress from sublethal exposure to or intake of contaminants or discarded debris. This would cause disturbances and displacement of single birds or flocks. Chronic sublethal stress is often undetectable in birds. It can serve to weaken individuals (especially serious for migratory species), making them susceptible to infection and disease. Coastal and marine birds are commonly entangled and snared in discarded trash and debris. Many species would readily ingest small plastic debris, either intentionally or incidentally. Interaction with plastic materials may lead to permanent injuries and death. Much of the floating material discarded from vessels and structures offshore drifts ashore or remains within coastal waters. These materials include lost or discarded fishing gear such as gill nets and monofilament lines, which cause the greatest damage to birds. It is expected that coastal and marine birds would seldom become entangled in or ingest OCS-related trash and debris as a result of BOEMRE prohibitions on the disposal of equipment, containers, and other materials into offshore waters by lessees (30 CFR 250.40). In addition, MARPOL, Annex V, Public Law 100-220 (101 Statute 1458), which prohibits the disposal of any plastics at sea or in coastal waters, went into effect January 1, 1989. Despite these regulations, quantities of plastic materials are accidentally discarded and lost in the marine environment, and so a threat to individual birds remains within these areas.

Non-OCS-Related Impacts

Habitat Degradation

Habitat alteration has the potential to disrupt social behavior, food supply, and the health of birds that occur in the Gulf of Mexico. Vital habitat needs to be protected so that the ecosystem continues for the birds and their prey. Such activities may stress the animals and cause them to avoid traditional feeding and breeding areas or migratory routes. Many of these species are declining in numbers and are being displaced from areas along the coast (and elsewhere) as a result of the destruction of or encroachment on their preferred habitat(s). As these birds move to undisturbed areas of similar habitat, their presence may create or augment habitat utilization pressure on these selected areas as a result of intra- and interspecific competition for space and food.

Tanker Oil Spills and Spills Related to Oil and Gas Activities in Coastal State Waters and Any Improperly Directed Spill-Response Activities

Most offshore non-OCS-related spills occur from vessel and barge operations. Table 4-13 of the Multisale EIS lists annual oil-spill occurrence in the Gulf of Mexico. Based on the 2009-2012 Supplemental EIS's OSRA model for coastal spills ≥1,000 bbl, the estimated total number of spills is 3 per 6 years for the total of non-OCS sources; for offshore spills ≥1,000 bbl, the estimated total number of spills for non-OCS sources is ≤1 per year for tank ships and ≤1 per year for tank barges. In summary, mandatory use of waterbirds feeding areas at the sea surface and intertidal wetland zone, where spilled oil tends to accumulate, makes them extremely vulnerable to exposure to oil. Exposure to small amounts of oil may have a latent impact on birds and a delayed impact on their food supply. Mortality from oil spills is often related to numerous symptoms of toxicity. Oil spills in the cumulative case have the greatest potential impact on coastal and marine birds. Oil-spill impacts on birds from the total cumulative

scenario are expected to be moderate. The increment of oil spills from the CPA proposed action to the total cumulative impacts is expected to be negligible.

Pollution of Coastal Waters Resulting from Municipal, Industrial, and Agricultural Runoff and Discharge

Non-OCS-related activities and natural processes that can impact marine water quality include bilge water discharges from large ships and tankers, and coastal pollutants that are transported away from shore, including runoff, river input, sewerage discharges, industrial discharge, and natural seepage of oil and gas. There exists a wide variety of contaminant inputs into coastal waters bordering the Gulf of Mexico. Contaminants from non-OCS pollution of coastal waters resulting from municipal, industrial, and agricultural runoff and discharge may have acute or chronic, lethal or sublethal impacts. The dominant pollution source is the large volume of water from the Mississippi River, which drains over two-thirds of the contiguous United States. Major activities that have added to the contamination of Gulf coastal waters include the petrochemical industry, agriculture, forestry, urban expansion, extensive dredging operations, municipal sewerage treatment processes, marinas and recreational boating, maritime shipping, and hydromodification activities. Not as significant are large commercial waste disposal operations, livestock farming, manufacturing industry activities, power plant operations, and pulp and paper mills. Vessel traffic is likely to impact water quality through routine releases of bilge and ballast waters, chronic fuel and tank spills, trash, and domestic and sanitary discharges.

Aircraft and Military Activities Including Jet Training Overflights and Sonic Booms

Playback of aircraft overflight noise at 96 decibels (dB) inside incubators and at 131 dB outside a different kind of incubator did not substantially affect the hatchability of chicken eggs or the quality of hatched chicks. Playback of overflight noise of about 115 dB made hens stop sitting on eggs (Stadelman, 1958). Responses to sonic booms in chickens, young turkeys, and pheasants were less intense than low subsonic overflights (Bell, 1972). No effects of subsonic aircraft on nesting herring gulls were noted (Burger, 1981). Subsonic aircraft overflights flushed significantly more herring gulls than flushed immediately before or after the disturbances (Burger, 1981).

Nonconsumptive Recreation

Impacts of nonconsumptive recreation depend on many factors including species and type of recreation. Even visitation by those most interested in conserving wildlife can have detrimental effects (Carney and Sydeman, 1999). Visitation of nesting areas can generate conservation interest and money, but disturbance can cause birds to abandon a site that managers need to preserve (Carney and Sydeman, 1999). Most studies of the effects of visitors on waterbirds did not identify mechanisms of impact, determine relative effects of different kinds of disturbance, or control for confounding influences (Carney and Sydeman, 1999).

Some ornithologists have presumed that birds that do not fly in response to disturbance are seldom substantially stressed, but this hypothesis has not been tested. A raised heart rate may have serious energetic costs to birds that do not fly when approached. In that case, birds still maintain increased vigilance, are highly stressed, and may be expending large amounts of energy because of elevated metabolic rate. Behavior is an obvious event, which is why it is so often measured, but it does not always signify fitness costs of disturbance or relative fitness costs for different species or populations (Beale, 2007). A decision to avoid a type of behavior may be important. Birds may decide not to flee when fitness costs are greater than the fitness benefits of moving to alternative habitat (Gill et al., 2001). The decision should depend on the context that the bird-alternative habitat may be lacking or scarce, and frequent disturbances could cause frequent flights, creating severe fitness (energy) costs such as lost foraging time during flight and the energy cost of flight. Decisions to shift habitat should be constrained by the species' perceptual range, i.e., the distance from which individuals can perceive landscape elements (Frid and Dill, 2002). Energy reserve depletion is likely to affect reproductive effort and possibly population viability.

Sometimes flushing, alertness, and other antipredator responses to nonlethal stimuli should become stronger; the bird should become sensitized with repeated exposure to the stimuli (Frid and Dill, 2002).

In that case, bird populations would need to be protected by some type of conservation such as setback buffer distances posted on signs. Sensitization to disturbance in birds is a poorly studied phenomenon and should never be discounted without supporting data. For an example of possible sensitization, loom rate is the rate at which a predator or human disturbance proxy for a predator increases in size as it approaches; for predators or proxies moving at the same speed, loom rate is higher for nearby predators or proxies than for distant ones. As multiple exposures to the stimuli at different distances occur, the bird should increase its flight initiation distance to stimuli with higher loom rates. The bird will associate the high rate with closeness of the predator, becoming sensitized rather than habituated. The bird learns to recognize this high-loom-rate cue to danger of close predator approach (Frid and Dill, 2002).

Energy cost in birds is highest for flight. Flight in response to disturbance will result in increased energy requirements and feeding time, and increased flight time will reduce the total time for other activities (Korschgen et al., 1985; Belanger and Bedard 1990; Ely et al., 1999; Ackerman et al., 2004). Fleeing from disturbance may affect feeding ecology and the effects of predation in complex ways; staying put may increase or decrease fitness. Outdoor recreation, especially nature appreciation and bird watching, is expanding into refuges and putting additional stresses on wild populations (Klein et al., 1995; Schummer and Eddleman, 2003).

Ecotourists (including bird watchers and wildlife photographers) and outdoor recreators are not likely to be aware of the negative impacts that their presence may have on wildlife (Carney and Sydeman, 1999). Ecotourists can introduce high levels of disturbance to nesting waterbirds. Ecotourists often closely approach birds, return to the same sites repeatedly, and visit sites year-round. The beneficial adaptation of flushing to avoid predators may balance with costly and nonbeneficial flushing caused by humans.

Predation risk and its proxy (response to human disturbance) can impact reproduction via decisions about parental investment (Frid and Dill, 2002). Once parents have considerably invested in their offspring, they may protect their investment by remaining on the nest for the rest of the breeding season after a severe disturbance, but they may abandon their nest site the following year (Steidl and Powell, 2006).

The ultimate impact on a bird flock of a sufficient disturbance by aircraft and recreationists would depend on the overall vigilance of birds within a flock, the size of an individual flock (because in response to a disturbance resembling a predator the entire flock would flush), and the rate at which each flock is flushed per unit time.

Hypotheses for the value of flocking to birds focus especially on predator avoidance and foraging enhancement, but the relative contribution of different ecological factors to the adaptations(s) of flocks remain unclear (Beauchamp, 2004). Evolution of flocking may have occurred in birds preferring high-density clumped prey such as fruits and seeds, whose high densities assuage competition for food by dense flocks (Beauchamp, 2002). Dispersed foods, such as many insects and vertebrates, have lower abundance within clumps and a more uniform distribution, which may be matched by uniformly distributed solitary foraging birds (Beauchamp, 2002). Conspecific attraction allows individuals to locate clumps for other birds, forming a foraging flock (Beauchamp, 2002). Conspecific attraction makes little sense for resources with low abundance within clumps. Human disturbance occurs because birds respond to humans as if they were predators. Individuals in flocks may have evolved under substantial predation risks and flocking may dilute predation risk. However, foragers at the edge of a flock are often first in line during predator attacks and do not benefit from the same dilution of risk as neighbors in the center of the group (Beauchamp and Ruxton, 2008). In birds constrained to maximize feeding time that trades off with lower vigilance time, increased numbers of eyes and ears and prey dilution correlated with increased flock size and may result in reduced vigilance time per bird (Beauchamp, 2008). In a meta-analysis, group size was important but explained generally less than 20 percent of the variation in vigilance time per bird (Beauchamp, 2008).

Maintenance and Use of Navigation Waterways

Adverse impacts of navigation canals have substantial impacts on wetlands. Initial impacts are locally substantial, but largely limited to where canals and channels pass through wetlands. Current channels would not change as a result of the proposed action. In addition, no new channels would be

required. Periodic maintenance dredging is expected in existing OCS-related navigation channels through barrier passes and associated bars.

Collisions of Coastal and Marine Birds with Wind Turbines, Communication Towers, Lighted Structures, Windows, Power Lines, and Fences

Wide-scale, long-term, standardized, and systematic assessments of bird collisions are few (Manville, 2005; Drewitt and Langston, 2008). Data on the status of one-third of all North American bird populations is lacking (Manville, 2005). The most important structural factors related to collision probability may be size and lighting (Drewitt and Langston, 2008). No hypotheses for the apparent attraction of birds, especially nocturnally migrating songbirds, to lights have been conclusively supported (Drewitt and Langston, 2008). Birds that stopped at lighted structures during inclement weather migrated on when weather conditions improved. The location of structures along the flight path, especially for flocks of birds, influences collision mortality. Warning lights for aircraft on towers >200 ft (61 m) are mandatory in the United States (Drewitt and Langston, 2008). Birds that avoid collision with windows may become exhausted as the birds flutter against them, falling to the ground where they may be vulnerable to starvation or predation (Drewitt and Langston, 2008). Overall mortality caused by collision with tall buildings may be considerable (Drewitt and Langston, 2008). Window strikes may be the greatest cause of anthropogenic mortality in the United States, at least an order of magnitude greater than strikes with wind turbines, communication towers, tall buildings, and power lines (excluding distribution lines to residences and businesses) (Drewitt and Langston, 2008). Collisions with power lines and supporting towers can occur during inclement weather and during periods of migration, often causing death or permanent injury to birds (Avery et al., 1980; Avian Power Line Interaction Committee, 1994). By 2000, the estimated annual death toll from collision with communication towers was at least 4-5 million birds (Drewitt and Langston, 2008). A current estimate is 40-50 million deaths (Manville, 2005). Combining collision mortality estimates for communication towers, power lines, and window strikes, at least several hundred million birds are killed annually (Drewitt and Langston, 2008). The number of birds annually killed by collision with windows is 100 million to 1 billion birds, or 0.5-5 percent of the estimated 20 billion birds in the United States (Drewitt and Langston, 2008). Population mortality greater than 0.5 percent may have a serious impact (Drewitt and Langston, 2008). Rapid proliferation of structures in developed countries and their future inevitability in developing countries may cause serious future population declines in birds (Drewitt and Langston, 2008).

Disease

In the United States, the most commonly diagnosed bacterial bird diseases were avian cholera, chlamydiosis, and salmonellosis. The most commonly diagnosed viral diseases were duck plague, paramyxovirus, and West Nile virus, together causing almost all deaths due to infectious diseases; fungal and parasitical infections were relatively minor (Newman et al., 2007). Even the collection of mosquito abundance and prevalence data for West Nile virus study is costly, and now health departments are struggling to maintain budgets for these procedures (Kilpatrick et al., 2007). Captive-reared whooping cranes have been vaccinated with a DNA vaccine for the RNA West Nile virus, which offers temporary relief but interferes with the natural selection for immune resistance (Kilpatrick et al., 2007).

Chemical pollution, the most commonly reported cause of death in scientific publications and the most important OCS-related impact (from oil spills), is probably less significant than infectious diseases (Newman et al., 2007). The impact of influenza viruses on wild animal host survival, reproduction, and behavior are almost completely unknown (Vandegrift et al., 2010). The two most important groups of migratory birds that are natural reservoirs for influenza viruses are waterfowl and charadriiformes (including shorebirds and gulls) (Vandegrift et al., 2010). LaDeau et al. (2007) stated that "Emerging infectious diseases present a formidable challenge to the conservation of native species in the twenty-first century." The number of diagnosed bird deaths was greater for viruses than for bacterial infections, and algal blooms had a relatively minor effect (Newman et al., 2007).

Storms and Floods

Coastal storms and hurricanes can often cause deaths to coastal birds through collisions because of high winds; associated flooding destroys active nests. Nesting territories and colonial bird rookeries with optimum food and/or nest-building materials may also be lost. Elevated levels of municipal, industrial, and agricultural pollutants in coastal wetlands and waters expose resident birds to chronic physiological stress.

Coastal Development

The construction of buildings and other facilities is expected to continue to encroach on bird habitat in the northern Gulf of Mexico. Areal extent of the proportion of habitat lost may increase linearly with ecological consequences to birds. However, new research indicates that habitat loss may sometimes have a critical threshold above which it increases nonlinearly and with greater degree (higher slope) with increasing ecological consequences (Swift and Hannon, 2010). This conclusion is based on simulations and empirical studies. The presence of thresholds depends on the characteristics of species and landscapes. Most existing studies of thresholds have not used any formal statistical methods to identify their presence or value (Swift and Hannon, 2010).

Fisheries Interactions (negative impacts of decreased food resources by fisheries catch and incidental seabird bycatch, and positive impacts of increased food resources from discarded bycatch)

Commercial fisheries may accidentally entangle and drown or injure birds during fishing operations or by lost and discarded fishing gear. Seabird bycatch before regulation caused severe global declines in many seabird species. The longline fisheries in the Gulf of Mexico comprise pelagic tuna and swordfish, bottom shark, and bottom reef. The total incidental seabird bycatch for the bottom longline fisheries was one gull of unidentified species, two brown pelicans, one herring gull, and two unidentified seabirds from 2005 to 2008; for the pelagic fishery, it was one brown pelican and two unidentified seabirds from 1992 to 2005 (Hale and Carlson, 2007; Hale et al., 2007; Scott-Denton, personal communication, 2009; Hale et al., 2009; Beerkircher, personal communication, 2009). With recent volunteer monitoring or mandatory observation, cumulative impacts for future bird bycatch of longline fisheries on marine birds in the northern Gulf of Mexico are expected to be negligible. Competition for prey species may occur between birds and fisheries. Fisheries catch may reduce population densities of avian aquatic predators limited by food availability by taking substantial food away. Substantially increased food resources from discarded fishery bycatch may have the opposite (positive) impact. Both processes are of special concern because fisheries are a recent unnatural intrusion into the function of coastal communities and organisms may not have had time to adapt.

Summary and Conclusion

Activities considered under the cumulative activities scenario would detrimentally affect coastal and marine birds. It is expected that the majority of effects from the major impact-producing factors on coastal and marine birds are sublethal (behavioral effects and nonfatal exposure to or intake of OCS-related contaminants or discarded debris) and would usually cause temporary disturbances and displacement of localized groups inshore because the activities themselves are temporary. The net effect of habitat loss from oil spills, new construction, and maintenance and use of pipeline corridors and navigation waterways would alter species composition and reduce the overall carrying capacity of disturbed area in general.

The incremental contribution of the proposed action to the cumulative impact is negligible because the effects of the most probable impacts, such as sale-related operational discharges and helicopters and service-vessel noise and traffic, are estimated to be sublethal with some displacement of local individuals or groups. The cumulative effect on coastal and marine birds is expected to result in a discernible decline in the numbers of birds that form localized groups or populations, with associated change in species composition and distribution. Some of these changes are expected to be permanent and to stem from a net decrease in preferred habitat for all birds and critical habitat for endangered species.

Activities considered under the cumulative scenario would detrimentally affect coastal and marine birds. The net effect of habitat loss from oil spills, OCS pipeline landfalls, and maintenance and use of navigation waterways, as well as habitat loss and modification resulting from coastal facility construction and development, would alter species composition and reduce the overall carrying capacity of disturbed area(s) in general. These would be the most serious cumulative impacts on birds. However, the impacts from these activities with the CPA proposed action would be minimal. This is in part because an oil spill would affect a small portion of a bird group and because of the low number of pipeline landfalls and the regulations, technologies, and mitigation requirements that are in place for dredging and construction activities. It is expected that the majority of effects from the major impact-producing factors on coastal and marine birds are sublethal (i.e., behavioral effects from aircraft and vessel traffic and noise and bird-watching activities; and nonfatal exposure to or intake of trash, debris, and OCS-related contaminants from air emissions and degradation of water quality). Unregulated recreational activities may seriously stress birds because approach to birds by humans has uncertain consequences and because recreationists usually do not realize the sublethal consequences of intrusion.

Nocturnal circulation events at platforms are expected to have minimal and mostly sublethal impacts on migrating bird populations. This conclusion results from the confirmed low mortality from starvation for all birds that landed on the platforms examined by Russell (2005) and from the suggested sublethal stress in birds that dropped out of circulation. Behavioral impacts usually cause temporary disturbances and displacement of inshore flocks. Collisions of coastal and marine birds with structures such as power line towers are usually lethal. Disease is often lethal but it may be a part of natural avian population control unless the pathogen is introduced by humans, such as for the West Nile virus. Storms and floods are natural disturbances to which exposed organisms are generally adapted, except for hurricane storm surge, which is exacerbated by coastal wetland loss in Louisiana.

The effect of the CPA proposed action to the cumulative effect of programmatic activities on coastal and marine birds is expected to result in a small but discernible decline in the numbers of birds, with associated change in species composition and distribution. Some of these changes are expected to be permanent and to stem from either a net decrease in preferred food resources or displacement of food resources and/or a decrease in the availability of preferred or critical habitat.

The DWH event and resulting oil spill in Mississippi Canyon Block 252 and the related spill-response activities may impact birds that come into contact with oil and remediation efforts. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected coastal and marine bird environment. For the latest available information on oiled or affected birds documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov (2010c).

4.1.1.15. Gulf Sturgeon

The description of the existing condition of the resource and its habitat that follows best describes both the known and currently unknown conditions as affected by both the series of intense hurricanes (Katrina, Rita, Gustav, and Ike) and the DWH event. Post-storm monitoring of some of the coastal sturgeon populations has been completed and the resulting status of those populations are included as part of the existing conditions noted below. While the actual affects of the DWH event are currently unknown, it is estimated as of October 12, 2010, that Louisiana had 88 mi (142 km), Mississippi had 9 mi (14 km), and Florida had 1 mi (2 km) of shoreline exposed to moderate to heavy oiling. An additional 203 mi (327 km) of Louisiana, 81 mi (130 km) of Mississippi, 60 mi (97 km) of Alabama, and 114 mi (183 km) of Florida shoreline was exposed to light to trace oiling (USDOT, CG, 2010d). These estimates may represent a decrease from the amount of shoreline oiling noted on the FWS *Deepwater Horizon* Response site in September 2010, indicating that a total of 494 mi (795 km) of shoreline received light to trace amount as compared with the October 2010 estimate of 458 mi (737 km). During the same September period, 98 mi (158 km), 9 mi (14 km), and 2 mi (3 km) of shoreline was exposed to moderate to heavily oiling in Louisiana, Mississippi, and Florida, respectively (USDOI, FWS, 2010a). Some of the shorelines oiled are within the areas of the Gulf sturgeon critical habitat. The degree of shoreline oiling has decreased but the affect on these habitats is not known at this time due to the ongoing NRDA assessment process. A more accurate assessment of the existing conditions of this resource and its habitat will be forthcoming as monitoring information is gathered and results are made publicly available.

4.1.1.15.1. Description of the Affected Environment

A detailed description of Gulf sturgeon can be found in Chapter 3.2.7 of the Multisale EIS and in Chapter 4.1.10 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*), a subspecies of the Atlantic sturgeon (*Acipenser oxyrinchus oxyrhynchus*), has a subcylindrical body embedded with bony plates (scutes), a greatly extended snout, ventral mouth with four anterior chin barbels, and a heterocercal tail (Valdykov, 1955; Valdykov and Greeley, 1963). Adults range from 1.8 to 2.4 m (5.9 to 7.9 ft) in length, with females attaining a greater length and mass than males.

The NOAA Fisheries Service and FWS listed the Gulf sturgeon as a threatened species on September 30, 1991. Subsequently, a recovery plan was developed to ensure the preservation and protection of Gulf sturgeon spawning habitat (USDOI, FWS and Gulf States Marine Fisheries Commission, 1995). Critical habitat was proposed on June 6, 2002, in the *Federal Register* (67 FR 39105 39199) and was designated on April 18, 2003. Critical habitat is defined as specific geographic areas that are essential for the conservation of a threatened or endangered species and that may require special management consideration or protection. The following geographic areas in the GOM rivers and tributaries were included in the critical habitat designation:

- Pearl and Bogue Chitto Rivers in Louisiana and Mississippi;
- Pascagoula, Leaf, Bowie (also referred to as Bouie), Big Black Creek, and Chickasawhay Rivers in Mississippi;
- Escambia, Conecuh, and Sepulga Rivers in Alabama and Florida;
- Yellow, Blackwater, and Shoal Rivers in Alabama and Florida;
- Choctawhatchee and Pea Rivers in Florida and Alabama;
- Apalachicola and Brothers Rivers in Florida; and
- Suwannee and Withlacoochee Rivers in Florida.

The critical habitat also includes portions of the following estuarine and marine areas:

- Lake Pontchartrain (east of the Lake Pontchartrain Causeway), Lake St. Catherine, Little Lake, The Rigolets, Lake Borgne, Pascagoula Bay, and Mississippi Sound systems in Louisiana and Mississippi, and sections of the adjacent State waters within the GOM;
- Pensacola Bay system in Florida;
- Santa Rosa Sound in Florida;
- nearshore GOM in Florida;
- Choctawhatchee Bay system in Florida;
- Apalachicola Bay system in Florida; and
- Suwannee Sound and adjacent State waters within the GOM in Florida.

The primary constituent elements of these designated areas that are considered essential for the conservation of the Gulf sturgeon include abundant food items; riverine spawning sites with appropriate substrates; riverine aggregation sites; a flow regime necessary for normal behavior, growth, and survival of all riverine life stages; water quality with the characteristics needed for normal behavior, growth, and viability of all life stages; sediment quality needed for normal behavior, growth, and viability of all life stages; and safe and unobstructed migratory pathways necessary for passage within and between riverine,

estuarine, and marine habitats. The critical habitat for Gulf sturgeon encompasses approximately 1,730 river miles (2,783 river km) and 2,333 mi^2 (6,042 km^2) of estuarine and marine habitat. Major shipping channels have been excluded in the critical habitat units.

The Gulf sturgeon is anadromous, with immature and mature fish participating in freshwater migrations. Gill netting and biotelemetry have shown that subadults and adults spend 8-9 months each year in rivers and 3-4 of the coolest months in estuaries or Gulf waters. The adult fish tend to congregate in deeper waters of rivers with moderate currents and sand and rocky bottoms. Seagrass beds with mud and sand substrates appear to be important marine habitats (Mason and Clugston, 1993). Individuals are long-lived, some reaching at least 42 years in age (Huff, 1975). Age of sexual maturity for females ranges from 8 to 17 years and for males it ranges from 7 to 21 years (Huff, 1975).

Gulf sturgeon eggs are demersal (sink to the bottom) and adhesive (Vladykov and Greeley, 1963). Spawning occurs in freshwater over relatively hard and sediment-free substrates such as limestone outcrops and cut limestone banks, exposed limestone bedrock or other exposed rock, large gravel or cobble beds, soapstone, or hard clay (Fox and Hightower, 1998; Marchent and Shutters, 1996; Sulak and Clugston, 1999). Although fry and juveniles feed in the riverine environment, subadults and adults do not (Mason and Clugston, 1993; Sulak and Clugston, 1999). Sturgeon feed on bottom-dwelling organisms such as amphipods, isopods, crustaceans, and marine worms.

Subadult and adult Gulf sturgeon spend cool months (October/November through March/April) in estuarine areas, bays, or in the GOM (Odenkirk, 1989; Clugston et al., 1995). Adult Gulf sturgeon likely overwinter in the GOM. Habitats used by Gulf sturgeon in the vicinity of the Mississippi Sound barrier islands tend to have a sand substrate and an average depth of 1.9-5.9 m (6.2-19.4 ft). Where estuary and bay unvegetated “mud” habitats have a preponderance of natural silts and clays supporting Gulf sturgeon prey, the Gulf sturgeon found there are assumed to be using these habitats only for foraging.

Sulak and Clugston (1999) describe two hypotheses regarding where adult Gulf sturgeon may overwinter in the GOM to find abundant prey. The first hypothesis is that Gulf sturgeon spread along the coast in nearshore waters in depths less than 10 m (33 ft). The alternative hypothesis is that they migrate far offshore to the broad sedimentary plateau in water depths of 40-100 m (131-328 ft) west of the Florida Middle Grounds. Available data support the first hypothesis. Evaluation of tagging data has identified several nearshore GOM feeding migrations but no offshore GOM feeding migrations. Telemetry data documented Gulf sturgeon from the Pearl River and Pascagoula River subpopulations migrating from their natal bay systems to Mississippi Sound and moving along the barrier islands on both the island passes (Ross et al., 2001). Gulf sturgeon from the Choctawhatchee, Yellow, and Apalachicola Rivers have been documented migrating in the nearshore GOM waters between Pensacola and Apalachicola Bay units (Fox et al., 2000). Telemetry data from the GOM mainly show sturgeon in depths of 6 m (19.8 ft) or less (Ross et al., 2001; Fox et al., 2000).

Gulf sturgeon occur in most major tributaries of the northeastern GOM from the Mississippi River east to Florida’s Suwannee River, and in the central and eastern Gulf waters as far south as Charlotte Harbor (Wooley and Crateau, 1985). In Florida, Gulf sturgeons are still found in the Escambia, Yellow, Blackwater, Choctawhatchee, Apalachicola, Ochlockonee, and Suwannee Rivers (Reynolds, 1993). While little is known about the abundance of Gulf sturgeon throughout most of its range, population estimates have been calculated for the Apalachicola, Choctawhatchee, and Suwannee Rivers. The FWS calculated an average (from 1984 to 1993) of 115 individuals (greater than 45 cm [18 in] total length) over-summering in the Apalachicola River below Jim Woodruff Lock and Dam (USDOI, FWS and Gulf States Marine Fisheries Commission, 1995). Preliminary estimates of the size of the Gulf sturgeon subpopulation in the Choctawhatchee River system are 2,000-3,000 fish over 61 cm (24 in) total length. The Gulf sturgeon subpopulation in the Suwannee River are 7,650 individuals over 60 cm (24 in) total length and older than age 2 (Sulak and Clugston, 1999). Although the size of the Suwannee River sturgeon population is considered stable, the population structure is highly dynamic as indicated by length frequency histograms (Sulak and Clugston, 1999). Strong and weak year-classes, coupled with the regular removal of larger fish, limit the growth of the Suwannee River population but stabilize the average population size (Sulak and Clugston, 1999).

Based on the latest population estimates from the Pearl River (Rogillio, personal communication, 2007; Kirk personal communication, 2007), the annual populations of sturgeon varied annually and ranged from 222 fish to 536 fish. The information noted the annual population estimates for the Pearl River population fluctuated as follows and was not stable as suggested in the earlier account referenced.

Year	Population Size (number of fish)
1992-1996	292
2000	222
2001	536
2002	246
2003	200
2004	277
2005	No estimate calculated

As noted, there is a great variance in population numbers. The researchers acknowledged that a better method of determining the health of the population is the mortality index. The acceptable range for annual mortality required to sustain the population in the Pearl River System was estimated in the range of 16-24 percent mortality. The estimate of annual mortality post-Hurricane Katrina is 38 percent, which is within the range indicative of insufficient recruitment to maintain the current Pearl River population (Kirk, personal communication, 2007). In 2005, there was no population estimate since the number of fish caught was insufficient to make an accurate estimate. The historic range of the Gulf sturgeon included nine major rivers and several smaller rivers from the Mississippi River, Louisiana, to the Suwannee River, Florida, and the marine waters of the central and eastern GOM to Tampa Bay (Wooley and Crateau, 1985; USDOI, FWS and Gulf States Marine Fisheries Commission, 1995). Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida. Sporadic occurrences have been recorded as far west as the Rio Grande River between Texas and Mexico, and as far east and south as Florida Bay (Wooley and Crateau, 1985; Reynolds, 1993).

Five genetically-based stocks have been identified by NOAA Fisheries Service and FWS: (1) Lake Pontchartrain and Pearl River; (2) Pascagoula River; (3) Escambia and Yellow Rivers; (4) Choctawhatchee River; and (5) Apalachicola, Ochlockonee, and Suwannee Rivers. Mitochondrial DNA analyses of individuals from subpopulations indicate that adults return to natal river areas for feeding and spawning (Stabile et al., 1996). While some displacement of Gulf sturgeon was noted after Hurricane Katrina, mortality was minimal for populations from the Pearl River drainage and Louisiana along the western range of the critical habitat (Kirk, 2008). It was also noted that, despite the location of juvenile populations of sturgeon in the lower Pearl River, there was no summertime use of either the Mississippi River Gulf Outlet or the adjacent disposal sites (Kirk, 2008).

Until recently, only two spawning sites were known, both in the Suwannee River in Florida. Eggs have now been discovered in six locations within the Choctawhatchee River system in Florida and Alabama (Fox and Hightower, 1998). In the Choctawhatchee Bay system, sturgeon were found in nearshore water depths of 2-4 m (7-13 ft). Areas of the bay where the Gulf sturgeon remained for long periods were characterized by sandy substrates with benthic communities dominated by crustaceans and annelids. Most of the male sturgeon remained in the Choctawhatchee Bay during the winter and spring, while most females were either in the Gulf of Mexico or last detected at the Bay entrance (Fox et al., 2002a). The Gulf sturgeon move from the 2- to 4-m (7- to 13-ft) water depth of the bays to the deeper waters around barrier islands but eventually relocate to shallow waters again. Both in the deeper and shallow waters they demonstrate localized movements within the area for extended lengths of time (>2 weeks) but then rapidly move to another area where localized patterns of movement are once again observed (Fox et al., 2002a). Based on these studies, it is believed that the deepwater areas are used primarily to return to the shallow foraging areas. In spring, large subadults and adults that migrate from the estuaries or the Gulf into major river passes feed primarily on lancelets, brachiopods, amphipods, polychaetes, and globular molluscs. Small sturgeons that remain in river passes during spring feed on amphipods, shrimp, isopods, oligochaetes, and aquatic insect larvae (Clugston, 1991). During the riverine stage, adults cease feeding, undergo gonadal maturation, and migrate upstream to spawn. Spawning occurs in freshwater reaches of the river, over coarse substrate in deep areas or holes with hard bottoms

and where some current is present (Sulak and Clugston, 1998; Fox et al., 2000). Females lay large numbers of eggs. A large female was reported to have the capability of producing 275,000-475,000 eggs (Chapman at al., 1993). These eggs are adhesive and attach to rocks, vegetation, or other objects. They hatch in about 1 week depending upon the temperature of the water.

Fisheries scientists interrupt migrating Gulf sturgeon in the rivers and estuaries by capture with nets suspended from floats in the rivers and river mouths to determine if these fish are showing signs of natal river fidelity. Gill nets with mesh wide enough not to close the very large opercula are used. No capture or tracking is feasible in the open Gulf when the fish migrate because cold fronts come every 2 to 3 days, with seas up to 9 ft (3 m). These conditions are dangerous for the size of vessel required, and the paths traveled in the open Gulf cannot be followed beyond the estuaries. Thus, the offshore winter distribution of Gulf sturgeon relative to the location of the activities under the proposed action is unknown. However, there have been no reported catches of this species in Federal waters (Sulak, personal communication, 1997).

Sturgeons are bottom suction feeders that have ventrally located, highly extrusible mouths. The sturgeon head is dorsoventrally compressed with eyes dorsal so benthic food under the sturgeon's mouth is not be visible. They have taste barbels, like catfish, to detect benthic prey. The barbels are also useful for feeding in high-order streams if visibility is low or at night. Fishes that forage by taste are opportunistic feeders because smell is much more discriminating than taste. Another adaptation of sturgeon to mainstem rivers and offshore waters is mobility (an adaptation to the large habitat scale). Studies (Parauka, personal communication, 2008) indicate Gulf sturgeon overwinter in the bays (Choctawhatchee, Escambia, and Santa Rosa) before migrating into the coastal rivers the following spring and summer. It was also noted that sturgeon leaving the Choctawhatchee Bay during the winter may utilize the surrounding bays and the Gulf of Mexico. Some adult sturgeon have migrated >100 km (62 mi) into the marine environment. While it has been hypothesized that some adults may remain in the open Gulf for as much as 2 years, the location of the Gulf foraging grounds is still unknown (Fox et al., 2002b). In this study, the primary food source was found to be the ghost shrimp. High fecundity (egg number) facilitates wide dispersal, a major adaptation to the high variance of habitat quality resulting from diverse habitats and the dynamic nature of mainstems of watersheds.

The decline of the Gulf sturgeon is believed to be due to overfishing and habitat destruction, primarily the damming of coastal rivers and the degradation of water quality (Barkuloo, 1988). In the late 19th century and early 20th century, the Gulf sturgeon supported an important commercial fishery providing eggs for caviar, flesh for smoked fish, and swim bladders for isinglass (a gelatin used in food products and glues) (Carr, 1983). Dams and sill construction mostly after 1950 restricted access to historic spawning areas (Wooley and Crateau, 1985) exacerbating habitat loss, and overfishing resulted in the decline of the Gulf sturgeon throughout most of the 20th century. In several rivers throughout its range, dams have severely restricted sturgeon access to historic migration routes and spawning areas. Dredging and other navigation maintenance that includes lowering river elevations, eliminating deep holes, and altering rock substrates may have adversely affected Gulf sturgeon habitats (Wooley and Crateau, 1985). Contaminants, both agricultural and industrial, may also be a factor in their decline. Organochlorines have been documented to cause reproductive failure in the Gulf sturgeon, reduced survival of young, or physiological alterations in other fish (White et al., 1983). In addition, Gulf sturgeon appear to be natal spawners with little, if any, spawning from other riverine populations.

Today, the greatest habitat threat to sturgeon is the damming of coastal rivers because sturgeon cannot pass through the lock and dam systems to reach spawning areas. In addition to damming, reservoir control and fluctuation of release rates during drought conditions are all factors affecting the spawning rivers downstream of major urban water supply reservoirs. Dredging, desnagging, and spoil deposition associated with channel maintenance and improvement also present a threat to sturgeon spawning habitat. Poor water quality because of pesticide runoff, heavy metals, and industrial contamination may be affecting sturgeon populations. Habitat loss continues to pose major threats to the recovery of the species.

Natural phenomena such as tropical storms and hurricanes occur along the Gulf Coast with varying frequency and intensity between years. Although these are usually localized and sporadic, the 2004-2005 storm seasons brought major and repeated damage to the Gulf Coast area. The effects from Hurricane Katrina (2005) are still being assessed. It was noted that Hurricanes Gustav and Ike did initially displace some of the Gulf sturgeon in the Louisiana/Mississippi area, much like what happened in Florida during

Hurricane Katrina. Current surveys along the Mississippi coast indicate no permanent impact to critical habitat and acknowledge that the sturgeon has returned to their normal feeding and resting areas along the coastal rivers. Sampling is not complete to conclude if the population had any change in composition or if spawning occurred this year (Slack, personal communication, 2008). While a complete assessment of habitat damage due to hurricanes has not been fully executed for Gulf sturgeon based on the recent sampling results, the effects are believed to be temporary (Parauka, personal communication, 2007a).

The impacted area included a large portion of the designated critical habitat and known locations of Gulf sturgeon. The sturgeons are upstream in freshwater riverine habitats during the tropical weather season. This may give the estuarine and marine areas time to recover from hurricane impacts before the sturgeon move downstream. For instance, massive runoff due to flooding rains and swollen tributaries could cause a sharp increase in toxic contaminants in estuarine habitats. However, spreading and dilution should mitigate any threat to sturgeon very quickly. By the time the downstream migration occurs, conditions should have returned to near normal. The flooding and subsequent "unwatering" of New Orleans in the fall of 2005 created concern for any sturgeon that might have been in the areas of Lake Pontchartrain where those contaminated flood waters were pumped. The COE noted in their environmental assessment that temporary impacts to Gulf sturgeon may have resulted as a part of the unwatering activities related to the pumping of floodwaters into Lake Pontchartrain. Impacts due to the quantity and quality of the floodwaters may have caused some sturgeon to seek forage and resting areas in other more undisturbed locations of the lake. It was expected that any sturgeon displaced returned to the area once the unwatering activities ceased (U.S. Dept. of the Army, COE, 2005a). The COE also noted that the emergency procedures permitted in the Panama City, Florida, aftermath of Hurricane Ivan may have created temporary impacts to species including the Gulf sturgeon, but that the emergency procedures did not adversely impact the species (U.S. Dept. of the Army, COE, 2005b). After Hurricane Katrina, there were reports of fish kills and at least one confirmed report of a dead Gulf sturgeon due to low oxygen in the water from organic input from leaf litter and other sources such as raw sewage and untreated effluent (Cummins, 2005). Many municipalities or sources of discharges lost power and/or were flooded and were likely a source of contaminant discharge.

Aside from the recent hurricane activity, the DWH event released an estimated 4.9 million barrels of oil into the Gulf of Mexico continuously over a 3-month period. Comparison of oil-spill overlay maps with the Gulf sturgeon critical habitat maps indicate that all but the most eastern regions of the sturgeon habitat has been exposed to oil (USDOC, NOAA, 2010f). The "oil exposed" habitat is found from the Chandeleur Islands in Louisiana to the mouth of the Pearl River and adjoining estuaries in both Louisiana and Mississippi, along the Gulf Islands National Seashores through Mobile Bay along the Alabama and Florida coasts to central Florida. While the exposure to spilled oil was not continuous in all locations, all areas were either moderate to lightly oiled, either onshore or on the surface based on maps prepared by SCAT observers and posted on NOAA's ERMA website (USDOC, NOAA, 2010f). It is most probable that the oil reaching these areas from the spill site was either weathered, treated (with dispersant), or both. The toxicity cannot be verified at this time due to ongoing NRDA assessments in these areas. While these sturgeon habitats and foraging areas must be considered as oil-affected (USDOC, NOAA, 2010f), for the purpose of the existing environmental conditions for this resource, no assessment of effects can be made at this time due to lack of publicly available data. At this time, we do not know the condition of the oil reaching the affected areas nor do we know the extent of oil that may be on the bottom in these potential foraging areas. As the NRDA assessment process proceeds, the oil on the surface as well as on the bottom will be mapped and the data will be forthcoming.

4.1.1.15.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of the Gulf sturgeon for the CPA proposed action can be found in Chapter 4.2.2.1.9.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.10.1.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Potential impacts to the threatened Gulf sturgeon and their designated critical habitat from routine activities associated with the CPA proposed action may occur from drilling and produced-water discharges, degradation of estuarine and marine water quality from runoff, vessel traffic, explosive removal of structures, and pipeline installation. Designated Gulf sturgeon critical habitat occurs in estuarine and riverine locations along the Gulf Coast east of the Mississippi River in Louisiana to Florida. Critical habitat is defined as special geographic areas that are essential for the conservation of a threatened or endangered species and that may require special management and protection. Designated Gulf sturgeon critical habitat is confined to State waters, and navigation channels are exempt from the critical habitat status. Most activities related to the proposed action would occur in Federal waters (i.e., structure placement, drilling, removal, etc); however, critical habitat may be impacted directly or indirectly.

Proposed Action Analysis

Drilling mud and produced-water discharges contain chemical components that may be detrimental or toxic to Gulf sturgeon. Toxicity from drilling muds would require concentrations four or five orders of magnitude higher than concentrations found a few meters from the discharge point. Produced-water discharges may result in moderate heavy-metal and hydrocarbon contamination of sediments and extend through the water column out to several hundred meters down current from the discharge point (CSA, 1997a). However, offshore discharges of drilling muds and produced waters are expected to dilute to background levels within 1,000 m (3,281 ft). These structures would be located well offshore of the designated critical habitat. Sturgeon are not known to be attracted to petroleum structures or activity, which is where the discharges would be the most concentrated.

Minor degradation of estuarine water quality is expected in the immediate vicinity of shore bases and other OCS-related facilities as a result of routine effluent discharges and runoff. Rapid dilution is expected to negate any impact to critical habitat or Gulf sturgeon from these sources.

Service-vessel traffic running in and out of shore bases may create the potential for impact to Gulf sturgeon. Ongoing movement studies currently being conducted off the northwest Florida coast noted Gulf sturgeon are found at mid-depth in the water column as opposed to bottom depths where they have previously been found (Nunley 2010; Robydek and Nunley, 2010). This finding, coupled with the movement between rivers and bays, provides more opportunity for vessel strikes. However, this behavior is currently only documented in Florida waters, which are far removed from the heavily traveled support bases west of the Mississippi River. There is potential for oiled sediments to be resuspended by vessel traffic in the areas where heavy oil was observed near support channels. Major shipping channels, as identified on standard navigation charts and marked by buoys, are excluded from critical habitat designation. Because Gulf sturgeon are bottom-feeders and are not known to be attracted to areas of activity or disturbance, the probability of a take due to vessel strike is extremely low in the areas located west of the critical habitat. Dredging of navigation channels and other areas is an impact to Gulf sturgeon critical habitat. However, only a small amount of the routine dredging done in coastal areas would be directly or indirectly due to the proposed action.

Platform removal using explosives has the potential to injure or kill a Gulf sturgeon in the near vicinity of a blast. However, current data indicate that Gulf sturgeons generally remain in the estuarine regions near river mouths or in shallow Gulf waters. Critical habitat is in State waters, well inshore of the location of any oil or gas structure installed as a result of the proposed action. In the very unlikely event that a Gulf sturgeon was far enough offshore to be in the area of an impending structure removal, the associated disturbance and activity is expected to deter the fish from approaching the removal site.

Pipeline installation may have the greatest potential for impact to Gulf sturgeon and their critical habitat from the CPA proposed action. Typical methods to lay pipeline can result in bottom and sediment disturbance, burial of submerged vegetation, reduced water clarity, reduced light penetration, and the resulting reduction of seagrass cover and productivity. With these methods, it is assumed that about 5 m^2 (55 ft^2) of sediments per kilometer of pipeline would be resuspended during the installation of 50-850 km (31-528 mi) of pipelines in water depths less than 60 m (200 ft). Such activity would impact the nearshore critical habitat of Gulf sturgeon.

All of the gas production and most of the oil production from the CPA proposed action is expected to be mingled in pipelines with other OCS production at sea before going ashore, and most would use

pipelines already in place. Zero to one pipeline landfall is projected as a result of the CPA proposed action. Should one be constructed, it would most likely be in Louisiana, where the large majority of the infrastructure exists for receiving oil and gas from the CPA. This area is on the extreme western end of the designated critical habitat for Gulf sturgeon.

Trenchless, or directional, drilling is a recent technique for pipeline installation that is used in sensitive habitats. Impacts from this technique are limited to the access and staging sites for the equipment, and Gulf sturgeon are expected to avoid lay-barge equipment as well as resuspended sediments. This method has been used successfully to place pipelines under scenic rivers so as not to disturb the bottom water or impact the banks of the river. Since 2002, only one new pipeline (Endymion oil pipeline) has come to shore in Louisiana from OCS-related activities. Based on a review of the data in the COE permit application, the emplacement of the pipeline caused zero (0) impacts to marshes and beaches because of the use of horizontal, directional (trenchless) drilling techniques to avoid damages to these sensitive habitats. Pipeline permit requirements of COE and State agencies are expected to require the reduction of turbidity impacts to within tolerable limits for submerged aquatic vegetation. These requirements, along with directional drilling capability, would result in impacts to Gulf sturgeon critical habitat that are short term and negligible, if they occur at all.

Summary and Conclusion

Potential routine impacts on Gulf sturgeon and their designated critical habitat may occur from drilling and produced-water discharges, bottom degradation of estuarine and marine water quality by nonpoint runoff from estuarine OCS-related facilities, vessel traffic, explosive removal of structures, and pipeline installation. Because of the permitted discharge limits mandated and enforced in the Federal and State regulatory process, the dilution and low toxicity of this pollution is expected to result in negligible impact of the CPA proposed action on Gulf sturgeon. Vessel traffic would generally only pose a risk to Gulf sturgeon when leaving and returning to port. Major navigation channels are excluded from critical habitat. Also, the Gulf sturgeon’s characteristics of bottom-feeding and general avoidance of disturbance make the probability of vessel strike extremely remote. Explosive removal of structures as a result of the proposed action would occur well offshore of Gulf sturgeon’s critical habitat and the riverine, estuarine, and shallow Gulf habitats where sturgeon are generally located. If any pipeline is installed nearshore as a result of the proposed action, regulatory permit requirements governing pipeline placement and dredging, as well as recent noninvasive techniques for locating pipelines, would result in very minimal impact to the Gulf sturgeon’s critical habitat. Due to regulations, mitigations, and the distance of routine activities from known Gulf sturgeon habitats, impacts from routine activities of the CPA proposed action would be expected to have negligible effects on Gulf sturgeon and their designated critical habitat.

4.1.1.15.3. Impacts of Accidental Events

A detailed impact analysis of the Gulf sturgeon for the CPA proposed action can be found in Chapter 4.4.9.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.10.1.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Potential accidental impacts on Gulf sturgeon and the designated critical habitat may occur from oil spills, drilling and produced-water discharges, degradation of estuarine and marine water quality by nonpoint runoff from estuarine OCS-related facilities, vessel traffic, explosive removal of structures, and pipeline installation.

Historically, Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Sporadic occurrences were recorded as far west as the Rio Grande River in Texas and Mexico, and as far east and south as Florida Bay (Wooley, 1985). The present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi, respectively, east to the Suwannee River in Florida. The species is anadramous—feeding in the winter months in the marine waters of the Gulf of Mexico including bays and estuaries, migrating in the spring up freshwater rivers to spawn on hard substrates, and then spending summers in the lower rivers before emigrating back out into estuarine/marine waters in the fall. Within the species’ present range, the critical habitat in the Gulf extends from Lake Borgne in

Louisiana to the Suwannee Sound in Florida. Although this is not the full range of occurrence of Gulf sturgeon, these areas constitute the most crucial habitat for the conservation of the Gulf sturgeon.

The critical rivers and their associated estuaries include the Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and the Suwannee Rivers. Reproducing populations continue to be evident in these seven river systems. Sturgeon reproduction is not known to currently occur in the Mobile Basin where it most likely occurred historically; however, slow recolonization may be occurring as evidenced by the recent catch of Gulf sturgeon near Fairhope, Alabama (Mettee et al., 2009). The estimated Gulf sturgeon population on the Suwannee River has increased from less than 500 in the 1980's to 2,000 fish in 2005 (Pine and Martell, 2009). The number of Gulf sturgeon in the Escambia River may have recently declined due to intense hurricane activity. Parauka (personal communication, 2007a) noted changes in distribution of sturgeon following Hurricane Katrina. There was a shift in sturgeon activity from the foraging areas in the Santa Rosa Sound and nearshore waters of Panama City, Florida, toward Mississippi Sound and Mobile Bay. However, several years after Hurricanes Katrina, Ike, and Gustav, these populations seem to have moved back to the Santa Rosa Sound area, but there has not been sufficient sampling to determine if the populations along this portion of the Gulf Coast have returned to pre-Katrina levels.

Recent studies found Gulf sturgeon movements may be influenced by the search for and availability of food, preferable hydrological conditions and spawning substrates. Brooks and Sulak (2005) noted while identifying food sources in the Suwannee Estuary that the benthic infauna biomass was greater in the summer than the winter and that the distribution of benthic food sources was patchy. During an assessment of the benthic food source in the Choctawhatchee Bay (Heard et al., 2002), a change in species composition was noted possibly as a result of nutrient overloading during Hurricane Ivan. This may explain the back and forth movement of sturgeon from this area to other areas where more benthic forage is available. Edwards et al. (2003 and 2007) noted patterns on tagged fish in the Suwannee Estuary that indicated the sturgeon in this area were searching for food where the supply was patchy; thus, erratic movements were observed. They also noted some consistent and directed movement patterns, indicating that these fish may remember where the most abundant food sources are located and return to these locations each year. These back and forth patterns of movement up and down the estuary as well as between rivers may explain both the lack of river fidelity and the sharing of marine and estuarine forage areas when food sources are not abundant.

Other important information about habitat use and distribution in Louisiana waters was shown in studies by Rogillio et al. (2007) and Ross et al. (2009). These studies documented the use of barrier-island passes in Mississippi Sound and the Chandeleur Islands for winter feeding. The FWS discovered nearshore areas of concentrated feeding activity for adults from multiple riverine systems in the waters near Tyndall Air Force Base/Panama City Beach, Florida, and Perdido, Florida, to Gulf Shores, Alabama (USDOI, FWS, 2002, 2003, 2004d, 2005b, and 2006b). Based on recent, buoy-based telemetry studies (Robydek and Nunley, 2008) in the offshore waters in northwest Florida, Gulf sturgeon were found to be more abundant in mid-water depths than noted in past studies where they were primarily noted as bottom dwellers, except when traveling between feeding sites. The occurrence in mid-water depths could increase the potential for vessel strikes during certain times of the year.

New spawning sites were verified by egg collection on the Apalachicola River, Florida (USDOI, FWS, 2006c; Pine et al., 2006; Scollan and Parauka, 2008), and the Yellow River, Florida (Kreiser et al., 2008). Juvenile movements in the Apalachicola River and Apalachicola Bay, Florida, were traced by Randall (2008). In June 2009, COE collected three young-of-the-year Gulf sturgeon in the Brothers River, a tributary to the Apalachicola River (Kirk, personal communication, 2010). Adult Gulf sturgeon were observed in a previously unreported tributary, the Withlacoochee River, Florida (Suwannee River tributary), in the fall of 2005 and in May 2006. Trophic habitat in the estuary of the Suwannee River, Florida, was described by Sulak et al. (2009). Juveniles (estimated age 8-9 months) were collected in the Santa Fe River, Florida, in December 2006 (Flowers and Pine, 2008); this observation is significant because the Santa Fe River is not known to support spawning and it is not known if the juveniles were spawned there or searching for habitat. Additional information was gained on feeding habits and movements in the estuary of the Suwannee River, Florida (Harris, 2003; Harris et al., 2005). Parkyn et al. (2007) described overall seasonal movements in the Suwannee River, Florida, drainage.

Proposed Action Analysis

Potential accidental impacts on Gulf sturgeon and the designated critical habitat may occur from oil spills, drilling and produced-water discharges, degradation of estuarine and marine water quality by nonpoint runoff from estuarine OCS-related facilities, vessel traffic, explosive removal of structures, and pipeline installation. The dilution and low toxicity of this pollution is expected to result in a negligible impact on Gulf sturgeon as a result of the CPA proposed action. Vessel traffic would generally only pose a risk to Gulf sturgeon when leaving and returning to port. Major navigation channels are excluded from critical habitat. The Gulf sturgeon's characteristics of bottom-feeding and general avoidance of disturbance make the probability of vessel strike extremely remote. However, recent studies have found that Gulf sturgeon spend more time than previously thought at mid-depth as opposed to being strictly utilizing the bottom, especially during movement from one area to another (Robydek and Nunley, 2008). Explosive removal of structures as a result of the proposed lease sale would occur well offshore of Gulf sturgeon critical habitat and the riverine, estuarine, and shallow Gulf habitats where sturgeon are generally located. Environmental permit requirements and recent techniques for locating pipelines would result in a very minimal impact to Gulf sturgeon critical habitat if any pipeline is installed nearshore.

Oil spills are the OCS-related factor associated with the CPA proposed action most likely to impact the Gulf sturgeon. The brief background information provided above is to provide insight into the factors in the sturgeons' life history and behavioral patterns that increase its susceptibility to accidental impacts associated with OCS activities. The coastal movements of Gulf sturgeon between estuaries, feeding in barrier island passes and utilizing both shallow and mid-water depths, increases the probability of encountering accidental spills. Other factors that may affect the sturgeon's probability of accidental impact is the Gulf sturgeon's long lifespan and extended residence in riverine and estuarine habitats, along with its benthic feeding habitats, which all enhance the chances of the species long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants including components of spilled oil.

The PAH studies specifically involving Gulf sturgeon were not found in the current literature, although Gulf sturgeon tissue samples were found to contain concentrations of PAH's (Batemann and Brim, 1994). The PAH toxicity to fish in general varies substantially, although impacts of PAH's on fish are often generalized due to the difficulty in testing any specific chemical. In areas of PAH contamination, fish may produce the means to allow for faster removal rates of PAH's from their system; however, this often transforms the PAH into a more harmful metabolite (O'Conner and Huggett, 1988). Fish exposed to PAH-contaminated sediments have experienced a range of affects including mortality, liver lesions, reproductive problems, fin erosion, skin carcinomas, and gill issues (Malins et al., 1985; O'Conner and Huggett, 1988; Fabacher et al., 1991; Varanasi et al., 1992; Baumann et al., 1996). There is also speculation that exposure to PAH's may suppress the immune system. Recent research has documented the occurrence of endocrine disruption in sturgeons from various chemical contaminants, and PAH contamination has resulted in endocrine and reproductive disruption in some salmonids (Matthiesson and Sumpter, 1998). Oil can affect Gulf sturgeon by direct ingestion, ingestion of oiled prey, or the absorption of dissolved petroleum products through the gills. Upon any exposure to spilled oil, liver enzymes of adult fish oxidize soluble hydrocarbons into compounds that are easily excreted in the urine (Spies et al., 1982). Contact with or ingestion/absorption of spilled oil by adult Gulf sturgeon could result in mortality or sublethal physiological impacts including irritation of gill epithelium and disturbance of liver function. Behavior studies of other fish species suggest that adult sturgeon are likely to actively avoid an oil spill, thereby limiting the effects and lessening the extent of damage (Baker et al., 1991; Malins et al., 1982). Fish eggs and larvae, with their limited physiology and mobility, are killed when contacted by oil (Longwell, 1977).

Accidental impacts associated with the CPA proposed action that could adversely affect Gulf sturgeon include oil spills associated with the transport and storage of oil. The degree of impact from oil spills depends on the location of the spill, oil slick characteristics, water depth, currents, time of year, and weather. Offshore oil spills that occur in the proposed action area are much less likely to contact the Gulf sturgeon or its critical habitat than are inshore spills because of the proximity of the spill to the critical habitat and known range of the sturgeon. Designated Gulf sturgeon critical habitat occurs in estuarine and riverine locations along the Gulf Coast east of the Mississippi River in Louisiana, Mississippi, Alabama, and Florida in the CPA. Designated Gulf sturgeon critical habitat is confined to State waters.

Most activities related to the proposed action would occur in Federal waters; however, critical habitat may be impacted directly or indirectly. Gulf sturgeon are primarily benthic feeders and inhabit mostly nearshore, coastal water environments of moderate depth, except during the riverine spawning period. Based on current studies (Parauka, personal communication, 2007b), the sturgeon seems to have preference for the nearshore waters and have not been tracked any farther seaward than the seaward side of the barrier islands. Currently, telemetry data are being collected through the NRDA and NOAA Fisheries in more seaward locations in response to the DWH event. There are no publicly available or published data concerning these more seaward locations at this time due to the NRDA assessment process. Spawning takes place when eggs are deposited in inland waters, and young Gulf sturgeon is believed to remain upstream for perhaps their first 2 years. The probability of spilled oil encroachment into an inland waterway is less than for the adjoining coastal area and diminishes even further as one moves upstream. Spilled oil is very unlikely to impact adult and juvenile Gulf sturgeon and eggs when they are in the inland, riverine portion of their life cycle. The juvenile and subadult Gulf sturgeon, at a minimum, seasonally use the nearshore coastal waters and could potentially be at risk from both coastal and offshore spills.

Because of the floating nature of oil and the small tidal range in the coastal Gulf, oil spills alone would typically have very little impact on benthic feeders such as the Gulf sturgeon. Unusually low tidal events, increased wave energy, or the use of oil dispersants increases the risk of impact with bottom-feeding and/bottom-dwelling fauna. For this reason, dispersants are not expected to be used with coastal spills. Winds and currents would also diminish the volume of a slick. For the Louisiana waters and beaches with a higher probability of oil-spill occurrence than the surrounding areas, the Mississippi River outflow would also serve to help break up a slick that might otherwise contact the area. Spreading of the slick would reduce the oil concentrations that might impact the coastal Gulf sturgeon critical habitat.

The potential risk to sturgeon would result from either direct contact with oil spills (or the potential PAH's introduced through the spill) or, in some cases, long-term exposure to produced water. The likelihood of Gulf sturgeon impacts in coastal waters as a result of OCS activity is reduced by both the distance from a potential spill or production area and the concentration of contaminants that actually reach the area of sturgeon activity. However, PAH studies involving Gulf sturgeon do not exist, although Gulf sturgeon tissue samples were found to contain PAH's (Batemann and Brim, 1994). Except for direct pipeline spills in the nearshore environment, the Gulf sturgeon would be at greater risk of a PAH encounter during the inland river migrations due to the industrial and farm waste introduced into these coastal rivers from the adjacent agricultural and urban land uses.

The produced waters associated with OCS activities have various chemical constituents that have varying potential for concern to the Gulf sturgeon. The components consist of metals, trace elements, monocyclic aromatic hydrocarbons, PAH's, and various organic chemicals. Berg (2006), in his literature review of contaminants that affect Gulf sturgeon, found that while pH and water hardness may have an affect on the availability and uptake of heavy and trace metals, some sturgeon species were seen to adsorb these compounds into their ovarian tissue and sperm at levels that reduced reproductive success. In general, many metals have similar impacts on fishes. The majority of metals accumulate externally in the mucous of the gill tissues, although metals also disrupt numerous physiological functions in fish (Berg, 2006). Since the Gulf sturgeon spends most of its time either in nearshore coastal environments or in inland rivers, the potential for encountering produced-water impacts or direct spills from a production platform is small. Produced water creates a localized area of effect close to the discharge and is mostly limited to benthic sediments in the immediate vicinity of the discharge. In the OCS activities, produced waters provide the main source of metals (i.e., arsenic, barium, cadmium, chromium, copper, lead, and zinc). While there have been no studies on the direct effects of these metals, specifically on Gulf sturgeon, there have been studies noting specific impacts of pollution and contamination (containing some or all of these metals and other waterborne contaminants) on various other sturgeon species. These studies identified the potential effects of these contaminants on sturgeon, which include muscle atrophy, abnormality of gonad, sperm and egg development, morphogenesis of organs, tumors, and disruption of hormone production (Graham, 1981; Altuf'yev et al., 1992; Dovel et al., 1992; Georgi, 1993; Romanov and Sheveleva, 1993; Heath, 1995; Khodorevskaya et al., 1997; Kruse and Scarnecchia, 2002). Mercury is only found occasionally in produced waters. All of these metals are natural constituents of clean seawater. Barium, chromium, copper, iron, nickel, and zinc are frequently found in produced water in higher concentrations than those naturally found in seawater. The complex geochemistry of these metals

affects their ability to produce adverse effects in the marine environment. Most of these metals are used as trace nutrients by marine organisms and, therefore, metal concentrations in the tissue make it difficult to determine bioaccumulation in these organisms. As a rule, concentrations of metals in tissues of marine organisms in the GOM and in the immediate vicinity of offshore discharges of produced water are in the normal range and do not show any evidence of bioaccumulation to potentially toxic levels for the organisms themselves or their consumers, including man (Neff, 2002). This study noted that produced water from the typical GOM produced water found only copper and cadmium, two metals typically in GOM produced water. Any adverse effects of these metals, if they occur at all, are likely to be highly localized.

The monocyclic aromatic hydrocarbons are found in produced water; however, because of their high volatility, they are lost rapidly in the seawater following discharge. Most of these volatile compounds are immediately diluted to background levels within 100 m (328 ft) of the discharge. The compounds have a low potential to be bioaccumulated by marine organisms and do not adsorb to sediments. Therefore, they pose a very low risk of harm to marine organisms and human consumers of seafood.

The PAH's have a low to moderate risk to marine organisms or human consumers of fishery products. Some PAH's bioaccumulate and are often found in sediments near produced-water discharges. Although some of the PAH's do have a tendency to bioaccumulate, those particular constituents are in such low concentrations in the produced water that they are considered to be low risk to marine ecosystems in the vicinity of the produced-water discharges. The major source of the more damaging PAH compounds are found as a component of soot from various combustion sources. The PAH associated with soot are not accumulated efficiently from the food sources and are biodegraded rapidly in the tissues of most marine animals; therefore, they do not biomagnify in the marine food web and do not pose a hazard to fish that consume biofouling organisms from submerged platform structures.

While not specifically addressing Gulf sturgeon, it has been observed that on other surrogate species such as brook trout, Caspian Sea sturgeon, and white sturgeon that sublethal concentrations of contaminants containing metals and hydrocarbon components may result in impaired physiological function and behavior in these fish species. The range of issues may include endocrine disruption, impacting reproduction and osmoregulation; immune system suppression; inhibition of the olfactory system; inhibition of the nervous system, interfering with behavior; and biochemical changes and developmental interference. All of these on their own may increase mortality and impair the recovery of a population or species (Berg, 2006).

Vessel traffic would generally only pose a risk to Gulf sturgeon when leaving and returning to port. Major navigation channels are excluded from critical habitat. The Gulf sturgeon's characteristics of bottom-feeding and general avoidance of disturbance make the probability of vessel strike extremely remote.

The coastal waters inhabited by Gulf sturgeon and comprising their critical habitat are not expected to be at risk from coastal spills resulting from the proposed action. However, based on the SCAT reports and maps produced by the FWS's *Deepwater Horizon* Response Team (USDOI, FWS, 2010a), critical habitat from Lake Borgne to the Florida/Alabama State line has at least been exposed to oil from the DWH event. It is not possible at this time to determine the type, condition, or volume of oil that contacted these areas due to the void of public data. It can be assumed that since the oil was treated with dispersant that it may sink, and depending on the condition (toxicity) of the oil, it may potentially affect the benthic forage in the areas where it blankets the bottom. There is a possibility that forage patterns and migration patterns of sturgeon may change along the coast if former foraging areas have been affected by the oil from the DWH event. Telemetry data concerning sturgeon movement are currently being collected from nearshore and offshore buoy systems by both NRDA and NOAA Fisheries. When this data becomes available, along with the NRDA data providing the location type and condition of the oil, an analysis will be able to be made on the effect of the DWH event on Gulf sturgeon and their habitat.

Several factors influence the probability of spilled oil contact with Gulf sturgeon or their critical habitat. The anadromous migrations and the spawning and lengthy habitations of inshore, riverine areas greatly diminish the probability of spilled oil contact with Gulf sturgeon. The floating nature of oil and the lack of large tidal ranges, as well as the influence of the Mississippi River outflow to help disperse slicks, diminishes the probability of significant impact of spilled oil on Gulf sturgeon or their critical habitat. The very low probability of a large offshore oil spill contacting the Gulf sturgeon's critical habitat in all but the very westernmost area diminishes the potential impact to Gulf sturgeon or alteration

of critical habitat. The extremely low probability of a coastal spill impacting east of the Mississippi River, and thus the designated critical habitat, diminishes the probability of oil impacts to critical habitat.

Summary and Conclusion

The Gulf sturgeon could be impacted by oil spills resulting from the CPA proposed action. If there is contact with spilled oil, it could have detrimental physiological effects. The juvenile and subadult Gulf sturgeon, at a minimum, seasonally use the nearshore coastal waters and could potentially be at risk from both coastal and offshore spills. Due to the distance of the activity from shore and Gulf sturgeon critical habitat, there is a minimal risk of any oil coming in contact with Gulf sturgeon. The probability of a spill of a size and duration to persist long enough in the environment to impact the sturgeon or the sturgeon's estuarine habitats is small (≤10%; Figure 3-10 of the 2009-2012 Supplemental EIS) unless it is catastrophic in nature such as the DWH event. In the rare event contact with oil occurs, this could cause nonlethal effects, including causing the fish to temporarily migrate from the affected area, irritation of gill epithelium, an increase of liver function in a few adults, and possibly interference with reproductive activity.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

4.1.1.15.4. Cumulative Impacts

A detailed impact analysis of the Gulf sturgeon for the CPA proposed action can be found in Chapter 4.5.9.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.10.1.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

This cumulative analysis summary considers activities that could occur and adversely affect Gulf sturgeon within its range and critical habitat in the northern Gulf of Mexico, east of the Mississippi River during the 40-year analysis period. These activities include effects of the OCS Program (the proposed action, and prior and future OCS lease sales), State oil and gas activity, coastal development, man-induced modifications to water quantity, water and air quality, crude oil imports by tanker, commercial and recreational fishing, coastal restoration and protection, and navigation and flood control projects, as well as natural phenomena. Specific types of impact-producing factors considered in this cumulative analysis include coastal and marine environmental degradation by nonpoint runoff from estuarine OCS-related facilities, produced-water discharges, pipeline emplacements, oil spills, dredge-and-fill operations and natural catastrophes that alter or destroy habitat, commercial fishing techniques that result in sturgeon bycatch, and man-induced salinity modifications.

Vessel traffic would generally only pose a risk to Gulf sturgeon when leaving and returning to port. Major navigation channels are excluded from critical habitat. The Gulf sturgeon's characteristics of bottom-feeding and general avoidance of disturbance make the probability of vessel strike extremely remote. The explosive removal of structures as a result of the CPA proposed action would occur far offshore of Gulf sturgeon critical habitat and the riverine, estuarine, and shallow Gulf habitats where sturgeon are generally located. Environmental permit requirements and recent techniques for locating

pipelines would result in very minimal impact to the Gulf sturgeon's critical habitat if any pipeline is installed nearshore as a result of a CPA proposed action.

Oil Spills

The Gulf sturgeon could be impacted by oil spills resulting from the CPA proposed action. The highest probability for cumulative impacts to the Gulf sturgeon or its habitat would be from coastal spills or vessel collisions in close proximity to its nearshore feeding and nursery areas. Due to the current distances of the CPA proposed action to the Gulf sturgeon's critical habitat, migratory routes, or nursery and feeding areas, there is a very low probability of impact from spills from this area unless it is catastrophic in nature, such as the DWH event (**Appendix B**).

Direct contact with spilled oil could have detrimental physiological effects. The juvenile and subadult Gulf sturgeon, at a minimum, seasonally use the nearshore coastal waters and could potentially be at risk from both coastal and offshore spills. However, several factors influence the probability of spilled oil contact with Gulf sturgeon or their critical habitat. The likelihood of spill occurrence and subsequent contact with, or impact to, Gulf sturgeon and/or their designated critical habitat is extremely low. Based on the 2009-2012 Supplemental EIS's OSRA model, there is <0.5 percent probability of oil spills (≥1,000 bbl) occurring and contacting Gulf sturgeon critical habitat as a result of an accidental spill occurring. Chapter 4.3.1.2 of the Multisale EIS describes the projections of future spill events in more detail.

For spills ≥1,000 bbl in the 2009-2012 Supplemental EIS, concentrations of oil below the slick are within the ranges that cause sublethal effects on marine organisms. However, when exposure time beneath accidental spills, hydrocarbon composition, and the change in this composition during weathering are considered, exposure doses are assumed to be far less than doses reported to cause even sublethal effects (McAuliffe, 1987). Given the low probability that Gulf sturgeon would be present in the specific area where and when a spill occurs, small likelihood of contact of a surface oil slick with a demersal fish and its benthic habitat, and minimal concentrations of toxic oil relative to levels that would be toxic to adult or subadult Gulf sturgeon, the impacts of spilled oil on this endangered subspecies are expected to be very low. With the DWH event, the oil was treated with dispersant, making the oil less toxic but causing the oil to sink and reach the benthic habitat. Normally, dispersants would be used in moderate amounts and only offshore so the benthic forage areas, as they are presently known and utilized by the sturgeon, would not be affected since the treated oil would sink in deepwater areas away from Gulf sturgeon nearshore habitat.

Regardless of spill size, the effects of direct contact from spilled oil on Gulf sturgeon occur through the ingestion of oil or oiled prey and the uptake of dissolved petroleum through the gills by adults and juveniles. Contact with or ingestion/absorption of spilled oil by adult Gulf sturgeon can result in mortality or sublethal physiological impacts, especially irritation of gill epithelium and disturbance of liver function. It is expected that the extent and severity of effects from oil spills would be lessened by active avoidance of oil spills by adult sturgeon. Sturgeons are demersal and would forage for benthic prey well below an oil slick on the surface. Adult sturgeon only venture out of the rivers into the marine waters of the Gulf for roughly 3 months during the coolest weather. This reduces the likelihood of sturgeon coming into contact with oil. It is expected that contact would cause sublethal irritation of gill epithelium and an increase in liver function for less than a month.

Based on currently available public information, it is reasonable to expect that oil production in the Gulf would continue to increase, although possibly at a slower rate due to economics of deepwater production and investment in other energy sources. In light of the DWH event and the impending cost of physical production modifications, regulations and safety requirements that may be needed to obtain a deepwater lease may reduce or temporarily delay the number of deepwater leases in production. This may have the effect of increasing shallow-water production, which could potentially result in adding a larger cumulative number of facilities closer to nearshore sturgeon habitat. If this happens, the potential for larger accidental spills closer to Gulf sturgeon critical habitat is possible. Currently, the toxicity, quantity, and the above and subsurface area of the oil spilled during the DWH event is unknown until the NRDA assessment is completed and made available. However, based on the available SCAT maps (USDOI, FWS, 2010a), the entire sturgeon critical habitat from Louisiana to eastern Florida was exposed to some portion of the spilled oil. What is not known is the condition of the oil and how much, if any,

effect it has had on the benthic forage base of the Gulf sturgeon. Since the oil was treated with dispersants, it should at least have a reduced toxicity; however, the treatment would also cause the oil to sink and therefore coat the ocean floor. Due to the season of the spill, the more vulnerable young sturgeon and larvae were still in the upper reaches of the rivers and not the estuary; therefore, they should be less affected.

Dredging, Channelization, and Dredged Material Disposal

Dredge-and-fill activities occur throughout the nearshore areas of the United States. These activities range in scope from propeller dredging (scarring) by recreational boats to large-scale navigation dredging and fill for land reclamation and coastal restoration projects. There will be a continual need for sand mining in coastal waters as a result of hurricane protection and coastal restoration projects. Other non-OCS operations, such as dredge-and-fill activities, indirectly impact Gulf sturgeon through the loss or disturbance of inland spawning and nearshore nursery habitat. Maintenance dredging and disposal to maintain navigation channels will continue to occur within Gulf sturgeon critical habitat (navigation channels are exempt from critical habitat) and may remove or modify foraging habitat as well as injure or kill some life history stages of the sturgeon. Hydraulic and mechanical dredging can lethally harm or kill various life stages of Gulf sturgeon. Of the three dredge types (hopper, clam, and pipeline), the hopper captured the most sturgeon (USDOI, FWS and USDOC, NMFS, 2009). The hopper dredges entrain young sturgeon either through the drag arm or the impeller pumps. Potential impacts from hydraulic dredge operations may be avoided by imposing work restrictions during sensitive time periods (i.e., spawning, migration, staging, and feeding) when sturgeon are most vulnerable to mortalities from dredging activity.

Dredged material disposal is to be used beneficially for wetland restoration or creation, therefore eliminating the covering of important benthic feeding areas or fringe wetlands. Depending on the time of year, dredging can potentially entrain eggs, larvae, or postlarval sturgeon within the coastal rivers or near the river mouths. The CPA proposed action would not require dredging near natal rivers used as migratory routes to upstream spawning areas. While there could be a need for maintenance dredging in the nearshore waters, juvenile or adult sturgeon using these areas have the ability to avoid the dredging activity. The construction and maintenance of navigation channels is regulated by COE, and dredging permits are “conditioned” to avoid and minimize impacts to Gulf sturgeon and their critical habitat. The permitted activity is “conditioned” with specific time windows to exclude dredging during times of sturgeon migration, spawning, or active use of critical nursery areas. These conditioned permits are coordinated with either FWS or NMFS or both, depending on the origin of the dredging operation. At present, BOEMRE’s coordination with NMFS indicates no changes in critical habitat have occurred, and they are working to develop an estimate of sturgeon habitat loss and a Habitat Suitability Index for the species (Bolden, personal communication, 2010). They also have no data indicating that sturgeons are using the deeper Gulf waters where most of the OCS activities occur. In general, the mud substrates found in the Gulf waters do not support the appropriate benthic food source for Gulf sturgeon.

Hurricanes and Other Natural Catastrophes

Natural catastrophes and non-OCS activities such as dredge-and-fill may destroy or temporarily impair Gulf sturgeon habitat. Natural catastrophes including storms, floods, droughts, and hurricanes can result in substantial habitat damage. The result of Hurricane Ivan studies by McLelland and Heard (2004 and 2005) demonstrated that the benthic forage base in the Choctawhatchee Bay was damaged and changed in composition as a result of the difference in sediment composition and nutrient loading. This lack of habitat caused Gulf sturgeon to temporarily abandon this feeding area. Parauka (personal communication, 2007a) noted an absence of Gulf sturgeon following Hurricanes Katrina, Rita, and Gustav in the Santa Rosa Sound. Further sampling indicated that the fish had moved to the Mobile Bay area but did return to the original Santa Rosa location within 1 to 1.5 years.

Loss of habitat is expected to have a substantial effect on the reestablishment and growth of Gulf sturgeon populations. Natural phenomenon such as tropical storms and hurricanes will continue to occur along the Gulf Coast with varying frequency and intensity between years. Although these are usually localized and sporadic, the 2004 and 2005 hurricane seasons brought major and repeated damage to the Gulf Coast area. The effects from Hurricane Katrina (2005) are still being assessed. As a result of

Hurricanes Katrina, Rita and Ike, sampling in the western portion of the range in Louisiana and Mississippi has been sparse. However, new studies to survey the Pearl River for Gulf sturgeon and to track its movements began in summer 2009 (USDOI, FWS and USDOC, NMFS, 2009, as per Bolden, personal communication, 2010). It was noted that Hurricanes Gustav and Ike did initially displace some of the Gulf sturgeon in the Mississippi-Louisiana area, much like what happened in Florida during Hurricane Katrina. Current surveys along the Mississippi coast indicate no permanent impact to critical habitat, and Parauka (personal communication, 2007a) acknowledged that the sturgeons have returned to their normal feeding and resting areas along the coastal rivers. Sampling is not yet complete to see if the population has had any change in composition or if spawning has occurred (Slack, personal communication, 2008).

The effects on Gulf sturgeon from COE's operation of Federal dams, water control structures including freshwater diversions, and reservoirs in the impacted area included a large portion of the designated critical habitat and known locations of Gulf sturgeon. The sturgeons are located upstream in freshwater riverine habitats during hurricane season. This may give the estuarine and marine areas time to recover from hurricane impacts before the sturgeon move downstream. For instance, massive runoff due to flooding rains and swollen tributaries could cause a sharp increase in toxic contaminants in estuarine habitats. Evaluations of water and sediment quality in Gulf sturgeon habitat on the northern Gulf of Mexico coast have consistently shown elevated pollutant loading. This has been observed in both tidal coastal rivers of the type that the sturgeon use in the spring and summer (Hemming et al., 2006 and 2008, as reported by USDOI, FWS, and USDOC, NMFS 2009). Perhaps better understood is the widespread contamination throughout the overwintering feeding habitat of the Gulf sturgeon (USDOI, FWS and USDOC, NMFS, 2009). However, spreading and dilution should mitigate any threat to sturgeon very quickly. By the time the downstream migration occurs, conditions should have returned to near normal.

Parauka (personal communication, 2007a) noted that his sturgeon monitoring program located fish that were displaced from the Panama City, Florida, area to Mobile Bay, Alabama. He noted this movement may have been as a result of damaged habitat in Florida; however, the return of the fish this year is indicative of habitat recovery. Similar absences were noted by Kirk and Rogillio (personal communication, 2007) in the Pearl River system, but again current monitoring indicates that the population of Gulf sturgeon is returning. The flooding and subsequent "unwatering" of New Orleans in the fall of 2005 created concern for any sturgeon that might have been in the areas of Lake Pontchartrain, which is where those contaminated floodwaters were pumped. The COE noted in their environmental assessment that temporary impacts to Gulf sturgeon may have resulted as a part of the "unwatering" activities related to the pumping of floodwaters into Lake Pontchartrain. Impacts due to the quantity and quality of the floodwaters may have caused some sturgeon to seek forage and resting areas in other more undisturbed locations of Lake Pontchartrain. It was expected that any sturgeon displaced returned to the area once the "unwatering" activities ceased (U.S. Dept. of the Army, COE, 2005a). After Hurricane Katrina, there were reports of fish kills and at least one confirmed report of a dead Gulf sturgeon due to low oxygen in the water from organic input from leaf litter and other sources such as raw sewage and untreated effluent (Cummins, 2005). Many municipalities or sources of discharges lost power or were flooded and were likely a source of contaminant discharge. The COE also noted that the emergency procedures permitted in the Panama City, Florida, aftermath of Hurricane Ivan may have created temporary impacts to species including the Gulf sturgeon, but that the emergency procedures did not adversely impact the species (U.S. Dept. of the Army, COE, 2005b). The hurricane impacts have not yet been fully assessed for Gulf sturgeon but are generally believed to be temporary (Parauka, personal communication, 2007a).

Unpredicted drought events in the upper river basins are currently impacting some of the Gulf sturgeon's riverine spawning habitat along the Apalachicola River in Florida. Recently, potential threats to the Gulf sturgeon's habitat in the Apalachicola River system and the receiving bays have been raised as a consequence of reducing river flow to meet upstream water needs during drought conditions in Georgia. It is expected with the current predictions of climate change that there will continue to be cyclic drought conditions that will persist in various regions of the sturgeon's range. This, combined with the increasing need for water from reservoirs in the urban areas north of the coast, will continue to be problematic for the conflicting needs for water. The OCS activities are primarily in deepwater marine locations outside of the inland spawning areas and migratory routes.

Red tides are caused by toxic marine algae that occurs in the Gulf of Mexico and is distributed Gulfwide. This algae contains a brevetoxin that causes paralysis, intoxication, irregular swimming motions, loss of equilibrium, convulsions, and regurgitation, which normally ends in death as a result of respiratory failure. Since the 1990's, the blooms of red tide have been increasing in frequency, with the most recent outbreak occurring in 2007 and 2008. Red tide was the probable cause of death for at least 20 Gulf sturgeons in Choctawhatchee Bay in 1999 (USDOI, FWS, 2000).

Commercial Fishing

Commercial fishing techniques such as trawling, gill netting, or purse seining, when practiced nonselectively, may impact species other than the target species. For example, Gulf sturgeons are a small part of the shrimp bycatch. It is estimated that for every 1.1 lb (0.5 kg) of shrimp harvested, 8.8 lb (4 kg) of bycatch is discarded (Sports Fishing Institute, 1989). The death of several Gulf sturgeons is expected from commercial fishing. Commercial fishing is expected to continue; however, the magnitude of the trawl fleet has been at least temporarily diminished by Hurricane Katrina. Aside from the "Katrina effect" on the industry, the Louisiana and Mississippi waters were closed to commercial fishing (including shrimp and oyster grounds) for 5 months as a result of the DWH event. In addition, increases in trawl density and successive trawling in one area may cause long-term impacts to the critical habitat.

Other Impact-Producing Factors

The cumulative and possibly repetitive effects of altering water flow in coastal rivers used by sturgeon for spawning may have long-term cumulative effects on the success of future spawning populations. Changes in climate may continue to alter weather patterns such that persistent drought conditions may naturally or artificially (alter flow for reservoir maintenance) reduce river flow over critical riverine spawning habitat and, in turn, may displace spawning activities closer to the coastal waters, increasing the vulnerability of sturgeon larvae to coastal and inland spills. Changes in climate may also increase flooding frequency and intensity, adding large amounts of both nutrients and toxins into the estuary. Warmer water, sea-level rise, and higher salinity levels could lead to accelerated changes in habitats utilized by Gulf sturgeon. Changes in water temperature may alter the growth and life history of fishes, and even moderate changes can make a difference in distribution and number (Florida Fish and Wildlife Commission, 2009). In addition, the currently proposed enlargement of coastal salt domes for use as oil-reserve storage will compromise flows in natal spawning rivers, as well as potentially increase salinity in the nearshore estuaries and bays (USDOI, FWS and USDOC, NMFS, 2009). As proposed, large amounts of freshwater will be removed from coastal rivers currently used by Gulf sturgeon and will be used to hydraulically mine the salt domes, producing a hypersaline effluent that will be piped to the coastal waters.

Access to historic Gulf sturgeon spawning habitat continues to be blocked by existing dams, and the ongoing operations of these dams also affect downstream habitat. Several new dams are being proposed that would increase these threats to the Gulf sturgeon and its habitat. Dams continue to impede access to upstream spawning areas and continue to adversely affect downstream habitat, including both spawning and foraging areas. The operation of the Federal reservoir in Georgia, which is controlled by COE, is affecting the spawning habitat of the Gulf sturgeon on the Apalachicola River in Florida. Two dams, Pools Bluff and Bogue Chitto Sills, also impact Gulf sturgeon movements in the Pearl River drainage. Upstream passage is likely possible over these structures during some flow conditions, but the extent to which passage occurs is still unknown. New studies to survey the Pearl River for Gulf sturgeon and to track their movements began in summer 2009 (Bolden, personal communication, 2010). Additional dams will be likely constructed in the future and will include dams on the Pearl River in Mississippi, Escambia River in Alabama, and Yellow and Apalachicola Rivers in Florida (USDOI, FWS and USDOC, NMFS, 2009). The cumulative effect of these and possibly others when combined with other environmental factors can considerably diminish the riverine spawning habitat for the Gulf sturgeon.

Summary and Conclusion

The Gulf sturgeon and its critical habitat can be cumulatively impacted by activities such as oil spills, dredging, alteration and destruction of habitat, natural catastrophes, commercial fishing, and onshore

alterations resulting in change in river flow and salinity modifications. The effects from contact with spilled oil would be sublethal and last for less than 1 month (Berg, 2006). Currently, there is no existing public data to ascertain the short-term and long-term effects of the DWH event on Gulf sturgeon or their critical habitat. It can be said that the critical habitat was exposed to oil and could possibly have been repeatedly exposed to oil in some cases. Until information is available on the quantity, type, and toxicity of the oil and where its' spatial subsurface location is, no assessment can be made to the benthic forage base of the Gulf sturgeon. Contact with spilled oil could have detrimental physiological effects. The juvenile and subadult Gulf sturgeon, at a minimum, seasonally use the nearshore coastal waters and could potentially be at risk from both coastal and offshore spills. However, several factors influence the probability of spilled oil contact with Gulf sturgeon or their critical habitat. Because of the low probability of an offshore oil spill from the CPA proposed action to impact Gulf sturgeon habitat (≤10%), Gulf sturgeon contact with oil is expected to be minimal. Also, the amount of oil projected to spill with a coastal spill is small (approximately 5 bbl) and it would have localized effects. The likelihood of spill occurrence and subsequent contact with, or impact to, Gulf sturgeon and/or their designated critical habitat is extremely low. Substantial damage to Gulf sturgeon critical habitat is expected from inshore alteration activities and natural catastrophes. As a result, it is expected that the Gulf sturgeon would experience a decline in population sizes and a displacement from their current distribution that would last more than one generation. Deaths of adult sturgeon are expected to occur from commercial fishing.

The incremental contribution of the CPA proposed action to the cumulative impact is negligible. This is because the effect of contact between sale-specific oil spills and Gulf sturgeon is expected to be sublethal and last less than 1 month, and regulations and mitigations decrease impacts from routine events.

The extent and scope of the spill resulting from the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the GOM under the 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the existing GOM Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed. The existing consultation recognizes that BOEMRE-required mitigations and other reasonable and prudent measures should reduce the likelihood of impacts from BOEMRE-authorized activities.

4.1.1.16. Fish Resources and Essential Fish Habitat

The BOEMRE has reexamined the analysis for fish resources and (EFH) presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for fish resources and EFH presented in the Multisale EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Fish resources and EFH could be impacted by coastal environmental degradation, marine environmental degradation, pipeline trenching, and offshore discharges of drilling discharges and produced waters associated with routine activities. The impact of coastal and marine environmental degradation is expected to cause an undetectable decrease in fish resources or in EFH. Impacts of routine discharges are localized in time and space, are regulated by USEPA permits, and would have minimal impact. Accidental events that could impact fish resources and EFH include blowouts and oil or chemical spills. A subsurface blowout would have a negligible effect on Gulf of Mexico fish resources. If spills due to the CPA proposed action were to occur in open waters of the OCS proximate to mobile adult finfish or shellfish, the effects would likely be nonfatal and the extent of damage would be reduced due to the capability of adult fish and shellfish to avoid a spill.

Impact-producing factors of the cumulative scenario that are expected to substantially affect fish resources and EFH include coastal and marine environmental degradation, overfishing, and to a lesser

degree, coastal petroleum spills and coastal pipeline trenching. At the estimated level of cumulative impact, the resultant influence on fish resources and EFH is expected to be substantial but not easily distinguished from effects due to natural population variations. The incremental contribution of the CPA proposed action to the cumulative impacts on fisheries and EFH would be small.

4.1.1.16.1. Description of the Affected Environment

A detailed description of the fish resources and EFH can be found in Chapter 3.2.8 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.11 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The Gulf of Mexico supports a great diversity of fish. Distribution of fish species are related to variable ecological factors that include salinity, primary productivity, and bottom type. These factors differ widely across the Gulf of Mexico and between the inshore and offshore waters. Characteristic fish resources are associated with the various environments and are not randomly distributed. Major gradients include rainfall and river output, bottom composition, and depth. High densities of fish resources are associated with particular habitat types. Most finfish resources are linked both directly and indirectly to the vast estuaries that ring the Gulf of Mexico. Estuaries serve as nursery grounds for a large number of marine fishes that live on the inner continental shelves, such as the anchovies, herrings, mojarras, and drums. Because of the variety of habitats, almost the entire GOM is within a designated EFH.

The Gulf also has some limited areas of smaller carbonate features often referred to as pinnacles offshore Mississippi and Alabama in the CPA. There are thousands of these carbonate mounds or pinnacles dotting the OCS of Mississippi/Alabama. They share many characteristics of patch reefs found in shallow tropical areas. The mounds are discrete, vary in size and structural complexity, and are surrounded by level sediment bottoms. The remaining OCS shelf, ranging to a depth of approximately 200 m (656 ft), generally has a muddy or silty soft bottom. Fish communities that occur on topographic features and pinnacles are described in Chapter 3.2.8.1 of the Multisale EIS. Deepwater demersal fishes below several hundred meters of depth are better known than the deep pelagic species. Extensive trawl sampling of Gulf of Mexico continental slope demersal fish are reported in a major Agency-funded, deep Gulf study (Gallaway, 1981).

Recently, hurricanes have been a prominent impacting factor to Gulf resources and have affected fish resources by destroying oyster reefs and by changing physical characteristics of inshore and offshore ecosystems. The intense hurricane season of 2005, including Hurricanes Katrina and Rita, did not affect the offshore fisheries as much as initially expected. By far, the worst resource devastation that occurred was for oyster populations, but even this fishery has recovered significantly, as evidenced in the Louisiana Dept. of Wildlife and Fisheries' Stock Assessment Report for the public oyster seed grounds (Louisiana Dept. of Wildlife and Fisheries, 2010a).

In September 2008, Hurricanes Gustav and Ike made landfall on the Gulf Coast. Hurricane Gustav came ashore southwest of New Orleans as a Category 2 storm, and Hurricane Ike made landfall as a Category 2 storm at Galveston, Texas. In April 2009, the Louisiana Dept. of Wildlife and Fisheries announced a $15.7 million cooperative research program with NOAA to monitor the recovery of Louisiana commercial fisheries impacted by Hurricanes Katrina, Rita, Gustav, and Ike (Louisiana Dept. of Wildlife and Fisheries, 2009). Caffey (personal communication, 2009) estimated revenue losses from Hurricanes Gustav and Ike on Louisiana fisheries and aquaculture sectors in excess of $98 million. The NOAA landings data show a drop in finfish harvest in both Louisiana and Texas, an increase in shrimp harvest in Texas, and a drop in shrimp harvest in Louisiana (USDOC, NMFS, 2008). This may be due to the loss of boats and infrastructure.

In September 2008, the Louisiana Dept. of Wildlife and Fisheries (2008a and 2008b) released preliminary, nonquantitative reports of the effects of Hurricanes Gustav and Ike on Louisiana fisheries. In it they noted the extensive marsh erosion and vegetative debris present in the canals of southeastern Louisiana, as well as localized fish kills, loss of marsh through erosion, and displacement and encroachment of saltwater into freshwater areas, a contributor to loss of essential fish habitat.

The DWH event in Mississippi Canyon Block 252, southeast of Venice, Louisiana, introduced large quantities of oil into the water column between the spill site and the marshes of the central Gulf Coast during the spring and summer of 2010. Oil from this incident has been observed to contact shorelines from Galveston, Texas, to Apalachicola, Florida, with the primary areas of oiling occurring from Grand Isle, Louisiana, west of the mouth of the Mississippi River to Santa Rosa Island, Florida. The oil penetrated estuaries at least along the Louisiana and Mississippi coasts and was driven farther inshore by the passage of Hurricane Alex, which made landfall near the Texas/Mexico border. All of these estuaries are extremely important nursery areas (EFH) for fish and aquatic life (Bahr et al., 1982). Oiling of these areas, depending on the severity, can destroy nutrient-rich marshes and erode coastlines, adding to the destruction caused by the recent hurricanes.

Early life stages of animals are usually more sensitive to environmental stress than adults (Moore and Dwyer, 1974). Oil can be lethal to fish, especially in larval and egg stages, depending on the time of the year that the event happened. Weathered crude oil has been shown in laboratory experiments to cause malformation, genetic damage, and even mortality at low levels in fish embryos of Pacific herring (Carls et al., 1998). Hernandez et al. (2010) recently studied seasonality in ichthyoplankton abundance and assemblage composition in the northern GOM off of Alabama. They found larvae representing 58 different families. Fish egg abundance, total larval abundance, and taxonomic diversity were significantly related to water temperature, not salinity, with peaks in spring, spring-summer, and summer. Detailed analyses of ichthyoplankton are not available east of this single sampling station nor west of it closer to the spill area. The patterns found in this study do indicate, however, that a possible mortality occurred in the larval fishes of the Gulf that came in contact with the spilled oil, depending on the timing of the spawn and the area influenced by the spill.

The use of dispersants adds to these uncertainties. Although *Corexit 9500*, the dispersant used, is believed to be the least toxic of all of its counterparts to small fish, its toxicity mixed with oil to specific species of ichthyoplankton is unknown. In July 2010, USEPA and NOAA proposed a monitoring program that will assess the toxicity of 20:1 oil/*Corexit* to Atlantic silversides.

The addition of *Corexit 9500* at the seafloor spill site and the surface resulted in the dispersion of oil in the water column. The addition of any carbon source such as oil can decrease dissolved oxygen due to microbial breakdown and was a particular concern during the DWH event due to the use of dispersants (**Chapter 4.1.1.2.1.1**). In areas where plumes of dispersed oil were previously found, dissolved oxygen levels decreased by about 20 percent from long-term average values in the GOM; however, scientists reported that these levels have stabilized and are not low enough to be considered hypoxic (USDOC, NOAA, 2010e). The drop in oxygen, which has not continued over time, has been attributed to microbial degradation of the oil.

Methane gas (CH_4) is commonly found in the Gulf of Mexico in concentrations of 6×10^{-5} milliliter/liter (ml/L) to 125×10^{-5} ml/L in the Gulf of Mexico (Frank et al., 1970). At their baseline levels, methane levels are controlled by methanotrophs (methane degrading bacteria) (Patin, 1999). Very little is really known about the effects of methane on fish. Patin (1999) reported elevated concentrations of methane, resulting from gas blowouts from drilling platforms in the Sea of Asov, resulted in significant species-specific pathological changes including damages to cell membranes, organs and tissues, modifications of protein synthesis and other anomalies typical for acute poisoning of fish. These impacts, however, were observed at levels of 1-10 ml/L.

Recently published research (Kessler et al., 2011) revealed that a large amount of methane was released by the during the DWH event and, based upon the methane and oxygen distributions measured at 207 stations in the affected area, a large amount of oxygen was respired by methanotrophs. Kessler et al. suggest that the methane triggered a large methanotroph bloom that rapidly degraded the methane, leaving behind a residual methanotrophic community.

How assemblages of fish have changed or will change as a result of the DWH event is unknown at this time. Adult fish tend to avoid contact with oil in the water column. Specific effects of oil on organisms can include direct lethal toxicity, sublethal disruption of physiological processes (internal lesions), effects of direct coating by oil (suffocation by coating gills), incorporations of hydrocarbons in organisms causing tainting or accumulation in the food chain, and changes in biological habitat (Moore and Dwyer, 1974).

In general, most reef fishes are associated with habitats on the continental shelf inshore of the spill. Most of these fish spawn during spring/summer and the larvae may be at risk, affecting recruitment in

future age classes. Surface feeders as menhaden and inhabitants of seagrass beds may be at risk depending on whether the oil floats or sinks. Sharks are commonly found Gulfwide in nearshore and offshore waters. Blacktip sharks and bull sharks are often found in estuaries Gulfwide and may be at risk, along with other estuarine species depending on the extent of the penetration of the oil into the estuaries.

Of particular concern are Gulf populations of bluefin tuna. The occurrence of bluefin tuna larvae associated with the Loop Current boundary and the Mississippi River discharge plume is evidence that these species spawn in the GOM (Richards, 1990). Block et al. (2001) also reported on the GOM being used as a breeding ground and demonstrated trans-Atlantic migrations of bluefin tuna between the eastern Mediterranean, Atlantic, and GOM using electronic data storage tags. The North Atlantic bluefin tuna has its peak spawning period in April and May in the Gulf.

The Western Atlantic stock has suffered a significant decline in spawning stock biomass since 1950, and a 20-year rebuilding plan has failed to revive the population or the North American fishery. The failure of the Gulf of Mexico spawning population to rebuild, as well as the scope of illegal and under-reported catches, particularly in the Mediterranean Sea, are of such major concern that the species was recently considered by the Convention for International Trade in Endangered Species for endangered species listing in March 2010. On September 21, 2010, NMFS announced a 90-day finding for a petition to list Atlantic bluefin tuna (*Thunnus thynnus*) as endangered or threatened under the Endangered Species Act and to designate critical habitat concurrently with a listing (*Federal Register*, 2010f).

Because of their decline in stock, the timing of their spawn in the Gulf, their buoyant eggs, and the timing of the DWH event, there is concern about further decline in the Gulf stock of bluefin tuna. The effects at this time are, however, unknown.

Thus far, only anecdotal (observational) evidence is available concerning fish kills. Offshore, a few small fish kills very near the spill site have been reported.. On the shelf and inshore also, a few, small fish kills have been reported that included common inshore species such as Atlantic croaker, anchovy, and menhaden.

During the DWH event, whale sharks were sited swimming in heavy oil 4 mi (6 km) from the spill site. These large, migratory sharks have been traced by satellite tags to come to the Gulf in the summer from as far away as Belize and Honduras. They are surface feeders, filtering plankton and tiny fish through their mouths. Oil poses a threat to them not only by direct ingestion but by coating their gills (Raines, 2010).

The severity and the duration of the effects of all of these factors on the fish assemblages and fisheries of the Gulf of Mexico are unknown at this time. New information relevant to the effects of the DWH event was sought in referenced journal articles, particularly those regarding the *Ixtoc* and *Exxon Valdez* spills, as well as government publications, white papers, and government Internet sites. All relevant literature was incorporated.

Essential Fish Habitat

In consideration of existing mitigation measures, lease stipulations, and a submitted EFH assessment document, this Agency entered into a Programmatic Consultation agreement with NMFS on July 1, 1999, for petroleum development activities in the CPA and WPA. This agreement was extended into that portion of the Eastern Planning Area known as Lease Sale 181.

Chapters 1.5 and 2.2.2 of the Multisale EIS discuss this Agency's approach to the preservation of EFH, with specific mitigations. Chapter 3.2.1 of the Multisale EIS details coastal areas that are considered EFH, including wetlands and areas of submerged vegetation. Chapter 3.2.2 of the Multisale EIS describes live-bottom formations and their biotic assemblages, which are considered EFH. Chapter 4.2.2.10 of the Multisale EIS contains the impact analysis of the proposed action on EFH. Chapter 4.4.3.10 of the Multisale EIS contains the impact analysis for accidental spills on EFH. Chapter 4.5.10 of the Multisale EIS contains the impact analysis of cumulative actions.

In 2005, a new amendment to the original EFH Generic Amendment was finalized (GMFMC, 2005). One of the most significant proposed changes in this amendment reduced the extent of EFH relative to the 1998 Generic Amendment by removing EFH description and identification from waters between 100 fathoms and the seaward limit of the EEZ. There are Fishery Management Plans in the Gulf of Mexico OCS region for shrimp, red drum, reef fishes, coastal migratory pelagics, stone crabs, spiny lobsters, coral and coral reefs, billfish, and highly migratory species.

A new EFH consultation has been initiated between BOEMRE's Gulf of Mexico Region and NOAA's Southeastern Region. Some of the EFH requirements may change with the new agreement. Until the new agreement is in place, the 1999 Programmatic Consultation with the elements described above will be the rule.

4.1.1.16.2. Impacts of Routine Events

Background/Introduction

A detailed description of the fish resources and EFH can be found in Chapter 3.2.8 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.11 of the 2009-2012 Supplemental EIS, and new information is presented in **Chapter 4.1.1.16.1** of this Supplemental EIS.

A detailed description of the possible impacts from routine activities associated with the CPA proposed action on fish resources and EFH is presented in Chapter 4.2.2.1.10 of the Multisale EIS and in Chapter 4.1.11.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the Supplemental EIS, and new information that has become available since both documents were prepared.

Effects on fish resources and EFH from routine activities associated with the CPA proposed action could result from coastal environmental degradation, marine environmental degradation, pipeline trenching, and offshore discharges of drilling discharges and produced waters. Since the majority of fish species within the CPA are estuary dependent, coastal environmental degradation resulting from the proposed action, although indirect, has the potential to adversely affect EFH and fish resources. The environmental deterioration and effects on EFH and fish resources result from the loss of Gulf wetlands and coastal estuaries as nursery habitat and from the functional impairment of existing habitat through decreased water quality.

Proposed Action Analysis

The routine impacts of the CPA proposed action on coastal wetlands and coastal water quality, with the exception of accidental events, are analyzed in detail in Chapters 4.2.2.1.3.2 and 4.2.2.1.2.1 of the Multisale EIS. Collectively, the adverse impacts from these effects are called coastal environmental degradation in this Supplemental EIS. The effects of the CPA proposed action on offshore live bottoms and marine water quality are analyzed in detail in Chapters 4.2.1.1.4.1.1 and 4.2.1.1.2.2 of the Multisale EIS. Collectively, the adverse impacts from these effects are called marine environmental degradation in this Supplemental EIS. The direct and/or indirect effects from coastal and marine environmental degradation on fish resources and EFH are summarized and considered below.

Coastal Environmental Degradation

A range of 0-1 new pipeline landfalls are projected in support of the proposed action (Chapter 4.1.2.1.7 of the Multisale EIS). Localized, minor degradation of coastal water quality is expected in waterbodies in the immediate vicinity of coastal shore bases, commercial waste-disposal facilities, and oil refineries or gas processing plants as a result of routine effluent discharges and runoff. There are 0-12 new gas processing plants projected in support of the CPA proposed action (Table 4-9 and Chapter 4.1.2.1.4.2 of the Multisale EIS).

Wetlands that could be impacted for some period of time or converted to open water are discussed in Chapter 4.2.2.1.3.2 of the Multisale EIS and in **Chapter 4.1.1.4.2** of this Supplemental EIS. A small amount of the routine dredging done in coastal areas could be a direct or indirect consequence of the proposed action. Some resuspension of bottom contaminants would be realized during dredging operations, although very little would be soluble in the water column and in bioavailable form. Since the proposed action would have minimal impact to the coastal environment, it is expected that coastal environmental degradation from the CPA proposed action would have little effect on fish resources or EFH.

Recovery of fish resources or EFH can occur from most, but not all, of the potential coastal environmental degradation. Fish populations, if left undisturbed, would regenerate quickly, but the loss

of wetlands as EFH could be permanent. At the expected level of effect, the resultant influence on fish resources or EFH from the CPA proposed action would be negligible and indistinguishable from natural population variations.

Marine Environmental Degradation

The Topographic Features Stipulation is discussed in Chapter 2.4.1.3.1 of the Multisale EIS, Chapter 2.2.1.3 of the 2009-2012 Supplemental EIS, and **Chapter 2.3.1.3.1** of this Supplemental EIS. The application of the guidelines outlined in NTL 2009-G39, “Potentially Sensitive Biological Features,” would also serve to prevent impacts to hard-bottom EFH habitat associated with topographic features that may be outside previously defined No Activity Zones. For any activities associated with the proposed action, USEPA’s Region 6 would regulate discharge requirements for the CPA through their NPDES permits. The projected total number of production structure installations resulting from the CPA proposed action (32-44) is for all water depths (**Table 3-2**). Bottom disturbance from structure emplacement operations associated with the proposed action would produce localized, temporary increases in suspended sediment loading, resulting in decreased water clarity and little reintroduction of pollutants. Structure removal results in artificial habitat loss and causes fish kills when explosives are used.

Most multi-leg platforms are removed by severing their pilings with explosives placed 4.6 m (15 ft) below the seafloor. It is projected that 14-17 structures in water depths <200 m (<656 ft) in the CPA would be removed using explosives as a result of the proposed action (**Table 3-2**). It is expected that structure removals would have a negligible effect on fish resources because these activities kill only those susceptible fish in close proximity to the removal site.

The projected length of pipeline installations for the CPA proposed action is 130-2,075 km (81-1,289 mi) for all water depths (**Table 3-2**). Trenching for pipeline burial has the potential to adversely affect fish resources. Any affected population is expected to recover to pre-disturbance condition quickly. At the expected level of impact, the resultant influence on fish resources would be negligible and indistinguishable from other natural population variations.

The major sources of routine discharges to marine waters associated with the CPA proposed action are the temporary discharge of drilling muds and cuttings and the long-term discharge of produced-water effluent. Drilling muds can contain materials such as mercury and cadmium, which may be toxic to fishery resources depending on their concentration; however, the discharge plume disperses rapidly. Therefore, the concentrations are near background levels at a distance of 1,000 m (3,281 ft) and are usually nondetectable at distances greater than 3,000 m (9,842 ft) (Kennicutt, 1995).

The toxicity of the metals associated with drilling muds also depends upon their bioavailability to organisms. Methylmercury is the bioavailable form of mercury (Trefry and Smith, 2003). In a study of methylmercury in sediments surrounding six offshore drilling sites, it was found that methylmercury concentrations did not vary significantly between nearfield and farfield sites (Trefry et al., 2003). Further, the study suggested that levels of methylmercury in sediments around drilling sites are not a widespread phenomenon in the Gulf of Mexico (Trefry et al., 2003). The discharge of drilling muds is, therefore, not anticipated to contribute to fish mortality either through direct exposure to discharged drilling muds or resuspension of muds through wave action or dredging.

Produced-water discharges contain components and properties potentially detrimental to fish resources, including trace metals, hydrocarbons, brine, and organic acids. Offshore discharges of produced water are expected to disperse and dilute to background levels within 1,000 m (3,280 ft) of the discharge point (CSA, 1997b). Because the produced water is highly diluted, it is not anticipated and has it been shown to cause fish mortality in populations surrounding platforms.

It is expected that marine environmental degradation from the CPA proposed action would have little effect on fish resources or EFH. The impact of marine environmental degradation is expected to cause an undetectable decrease in fish populations. Recovery of fish resources or EFH can generally occur from the potential marine environmental degradation. Fish populations, if left undisturbed, would regenerate quickly given the absence of catastrophic events. Offshore live bottoms and topographic features are not expected to be impacted.

Offshore discharges and subsequent changes to marine water quality would be regulated by USEPA NPDES permits. At the expected level of effect, the resultant influence on fish resources or EFH would be negligible and indistinguishable from natural population variations.

Other Factors

Structure emplacements can act as fish attracting devices and can result in aggregation of highly migratory fish species. A number of commercially important highly migratory species, such as tunas and marlins, are known to congregate around fish attracting devices. The attraction of pelagic highly migratory species to offshore structures would likely occur to some degree. Almost immediately after a platform is installed, the structure would be acting as an artificial reef. After just a few years, many of the fish species present would be residents and not new transients from nearby areas. Reef-building corals and other species such as black corals have also been documented colonizing numerous platforms (Sammarco et al., 2004; Boland and Sammarco, 2005).

Summary and Conclusion

It is expected that any possible coastal and marine environmental degradation from the CPA proposed action would have little effect on fish resources or EFH. The impact of coastal and marine environmental degradation is not expected to cause a detectable decrease in fish resources or in EFH. Routine activities such as pipeline trenching and OCS discharge of drilling muds and produced water would cause negligible impacts and would not deleteriously affect fish resources or EFH. This is because mitigation reduces the undesirable effects from dredging and other construction activities on coastal habitats. Permit requirements should ensure that pipeline routes either avoid different coastal habitat types or that certain techniques are used to decrease impacts. At the expected level of impact, the resultant influence on fish resources would cause minimal changes in fish populations or EFH. That is, if there are impacts, they would be short-term and localized; therefore, they would only affect small portions of fish populations and selected areas of EFH. As a result, there would be little disturbance to fish resources or EFH. In deepwater areas many of the EFH's are protected under stipulations and regulations currently set in place.

The BOEMRE has reexamined the analysis for impacts to fish resources and EFH presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented above. No substantial new information was found that would alter the overall conclusion that impacts to fish resources and EFH from routine activities associated with the CPA proposed action would be minimal to none. The CPA proposed action is expected to result in a minimal decrease in fish resources and/or standing stocks or in EFH. It would require a short time for fish resources to recover from most of the impacts. Recovery from the loss of wetlands habitat would probably not occur.

Additional hard substrate habitat provided by structure installation in areas where natural hard bottom is rare would tend to increase fish populations. The removal of these structures would eliminate that habitat, except when decommissioned platforms are used as artificial reef material. This practice is expected to increase over time.

4.1.1.16.3. Impacts of Accidental Events

Background/Introduction

A detailed description of accidental impacts upon fish resources and EFH in the CPA can be found in Chapter 4.4.10 of the Multisale EIS and in Chapter 4.1.11.3 of the 2009-2012 Supplemental EIS. The risk of oil spills from the proposed action has the potential to affect fish resources and EFH, and it is discussed in detail in Chapter 4.3.1 of the Multisale EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Further, the effect of accidental events from the CPA proposed action on coastal wetlands and coastal water quality is analyzed in Chapters 4.4.3.2 and 4.4.2.1 of the Multisale EIS and in Chapters 4.1.3.2.3 and 4.1.2.1.3 of the 2009-2012 Supplemental EIS. Both of these discussions are based upon oil untreated with dispersants. These are mentioned because they are important resources to fisheries species. Accidental events that could impact fish resources and EFH include blowouts and oil or chemical spills.

Proposed Action Analysis

Currently, the CPA proposed action is estimated to result in the drilling of a total of 65-121 exploration wells and 338-576 development and production wells. Of these production wells, 149-263 are estimated to be producing oil wells and 144-237 are estimated to be producing gas wells (**Table 3-2**). There is a 69-86 percent chance of one or more spills ≥1,000 bbl occurring. The most likely source or cause of an offshore spill is also discussed in Chapters 4.3.1.5.2 and 4.3.1.6.2 of the Multisale EIS. The most likely size of spill is the smallest size group (<1 bbl). Spills that contact coastal bays and estuaries would have the greatest potential to affect fish resources. The risks of an oil spill ≥1,000 bbl occurring and contacting county and parish shorelines and specific sensitive biological features were calculated and are presented in Figures 4-12, 4-13, 4-14, and 4-16 of the Multisale EIS. The probability of an oil spill ≥1,000 bbl occurring from the CPA and stranding on the Chandeleur Islands is calculated to be 3-5 percent over its 40-year life. The risk to other hard/live bottoms in the Gulf of Mexico such as the Pinnacle Trend was not calculated. Other areas of hard-bottom shelf (EFH) would potentially remain unharmed as spilled substances could reach the seafloor in small concentrations. This is because of the distances and time required for transportation from the deepwater areas of the CPA proposed action and the potential dispersion of oil.

There is a small risk of spills occurring during shore-based support activities, and the majority would be small in size. Most of these incidents would occur at or near pipeline terminals or shore bases and are expected to affect a highly localized area with low-level impacts. As a result of spill response and cleanup efforts, most of the inland spill would be recovered and what is not recovered would affect a small area and dissipate rapidly. A total of 15-34 coastal spills of all sizes are estimated to occur over the 40-year life of the proposed action (Chapter 4.3.1.7.1 of the Multisale EIS). It is also assumed that a petroleum spill would occasionally contact and affect nearshore and coastal areas important to Gulf of Mexico fisheries. These species are highly migratory and would actively avoid the spill area.

Blowout and Oil-Spill Impacts

Loss of well control and resultant blowouts seldom occur on the Gulf OCS. The potential causes and probabilities of blowouts are discussed in Chapter 4.3.1.2 of the Multisale EIS. A blowout with hydrocarbon release has a low probability of occurring as a result of the proposed action. Less than one blowout of ≥1,000 bbl is projected for the entire depth range of the CPA proposed action. A blowout with an oil release has a low probability of occurrence, but it is possible given the occurrence of the spill resulting from the DWH event.

Subsurface blowouts, although highly unlikely, have the potential to adversely affect fish resources. A blowout at the seafloor could create a crater and resuspend and disperse large quantities of bottom sediments. This potentially affects a limited number of resident and transient fish in the immediate area. The majority of mobile deep-sea benthic or near-bottom fish taxa would be expected to leave (and not re-enter) the area of a blowout before being impacted by the localized area of resuspended sediments.

Resuspended sediments can clog fish gills and interfere with respiration. Settlement of resuspended sediments may directly smother deepwater invertebrates that serve as food sources. However, coarse sediment should be redeposited quickly within several hundred meters or feet of a blowout site. Finer sediments can be more widely dispersed and redeposited over a period of hours to days within a few thousand meters or feet depending on the particle size.

Oil loss from a blowout is rare although possible. Less than 10 percent of blowouts in recent history have resulted in spilled oil. Gas blowouts consist mainly of methane, which rapidly dissolves in the water column or disperses upward into the air. These gas blowouts are less of an environmental risk. Loss of gas well control does not always release liquid hydrocarbons. The release of hydrocarbons with the gas is possible.

In the case of the DWH event (consisting of a combination of oil and gas), it has been suggested that the addition of dispersants at the seafloor has resulted in large subsurface clouds of elevated methane concentrations. These alleged areas of elevated methane concentrations may potentially result in areas of lowered dissolved oxygen concentrations due to the actions of methanotrophic bacteria. Literature on this subject is scarce, so little is really known about the effects of methane on fish. Methane gas (CH_4) is commonly found in the Gulf of Mexico in concentrations of 6 x10^{-5} ml/L to 125 x 10^{-5} ml/L in the Gulf of Mexico (Frank et al, 1970). Patin (1999) reported elevated concentrations of methane in the Sea of

Asov resulting from gas blowouts from drilling platforms. He reported that these levels resulted in significant species specific pathological changes. These include damages to cell membranes, organs and tissues, modifications of protein synthesis, and other anomalies typical for acute poisoning of fish. However, these impacts were observed at levels of 1-10 ml/L, which is higher than the background levels in the Gulf of Mexico.

Recently published research (Kessler et al., 2011) revealed that a large amount of methane was released by the DWH event and, based upon the methane and oxygen distributions measured at 207 stations in the affected area, a large amount of oxygen was respired by methanotrophs. Kessler et al. suggest that the methane triggered a large methanotroph bloom that rapidly degraded the methane, leaving behind a residual methanotrophic community.

The toxicity of an oil spill depends on the concentration of the hydrocarbon components exposed to the organisms (in this case fish and shellfish) and the variation of the sensitivity of the species considered. The effects on and the extent of damage to fisheries resources from a petroleum spill are restricted by time and location. Oil has the potential to affect finfish through direct ingestion of hydrocarbons or ingestion of contaminated prey. Hydrocarbon uptake of prey can be by dissolved petroleum products through the gills and epithelium of adults and juveniles, decreased survival of larvae, and through the death of eggs (NRC, 1985 and 2002a). It can also result in incorporations of hydrocarbons in organisms causing tainting or accumulation in the food chain and changes in the biological habitat (Moore and Dwyer, 1974).

The level of impacts of oil on fish depends on the amount of oil released, the toxicity of the oil, and the availability of bacteria to degrade the oil. The speed of degradation of the oil by bacteria is also related to the water temperature. Physical toxicity of oil to fishes depends on the application of dispersants and the toxicity of the dispersant. In the case of the DWH event, the application of the dispersant (*Corexit 9500*) at the seafloor and the surface was alleged to have had the potential to produce larger areas of subsurface anoxic water because of the degradation of oil by bacteria. The effect of oil on fishes is also related to the distance from the shore, the location in the Gulf of Mexico, and the time of the year that the spill occurs. In the case of the DWH event, however, few offshore and onshore fish kills have been observed in Louisiana (Bourgeois, written communication, 2010a), Mississippi (Devers, written communication, 2010), and Alabama (Denson, personal communication, 2010) (**Table 4-7).**

Accidental spills have the potential to affect sensitive species in the Gulf of Mexico, such as the bluefin tuna that spawn in the Gulf of Mexico in April-May (Block et al., 2001). The Western Atlantic stock has suffered a significant decline in spawning stock biomass since 1950, and a 20-year rebuilding plan has failed to revive the population or the North American fishery. The failure of the Gulf of Mexico spawning population to rebuild, as well as the scope of illegal and under-reported catches (particularly in the Mediterranean Sea) are of such major concern that the species was recently considered by the Convention for International Trade in Endangered Species for endangered species listing in March 2010. On September 21, 2010, NMFS announced a 90-day finding for a petition to list Atlantic bluefin tuna (*Thunnus thynnus*) as endangered or threatened under the Endangered Species Act and to designate critical habitat concurrently with a listing (*Federal Register*, 2010f). Because of their decline in stock from overfishing, the timing of their spawn in the Gulf, their buoyant eggs, and the timing of the DWH event, there is concern about further decline in the Gulf stock of blue fin tuna.

The effect of petroleum spills on fish resources as a result of the proposed action is expected to cause a minimal decrease in fish resources or standing stocks of any population. At the expected level of impact, the resultant influence on fish populations within or in the general vicinity of the proposed lease sale area would be negligible and indistinguishable from natural population variations.

Summary and Conclusion

Accidental events that could impact fish resources and EFH include blowouts and oil or chemical spills. Subsurface blowouts, although highly unlikely, have the potential to adversely affect fish resources. If spills due to the CPA proposed action were to occur in open waters of the OCS proximate to mobile adult finfish or shellfish, the effects would likely be nonfatal and the extent of damage would be reduced due to the capability of adult fish and shellfish to avoid a spill, to metabolize hydrocarbons, and to excrete both metabolites and parent compounds. Fish populations may be impacted by an oil spill but they would be primarily affected if the oil reaches the productive shelf and estuarine areas, and this

probability is generally low. Also, much of the coastal northern Gulf of Mexico is a moderate- to high-energy environment; therefore, sediment transport and tidal stirring should reduce the chances for oil persisting in these habitats if they are oiled. Early life stages of animals are usually more sensitive to environmental stress than adults (Moore and Dwyer, 1974). Oil can be lethal to fish, especially in larval and egg stages, depending on the time of the year that the event happened. The extent of the impacts of the oil would depend on the properties of the oil and the time of year of the event.

Fisheries closures may result from a large spill event. These closures may have a negative effect on short-term fisheries catch and/or marketability. In the long term, they may have a positive impact on species populations.

The effect of proposed-action-related oil spills on fish resources is expected to cause a minimal decrease in standing stocks of any population because most spill events would be localized; therefore, they would affect a small potion of fish populations. Historically, there have been no oil spills of any size that have had a long-term impact on fishery populations. Although many potential effects of the DWH event on the fish populations of the Gulf of Mexico have been alleged, the actual effects are at this time unknown and the total impacts are likely to be unknown for several years.

4.1.1.16.4. Cumulative Impacts

Background/Introduction

A detailed description of cumulative impacts on commercial fishing can be found in Chapter 4.5.10 of the Multisale EIS and in Chapter 4.1.11.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in those documents, and incorporates new information found since publication of the 2009-2012 Supplemental EIS.

This cumulative analysis summary includes effects of the OCS Program (the proposed action and past and future OCS lease sales), State oil and gas activity, coastal development, crude oil imports by tanker, commercial and recreational fishing, and natural phenomena. Specific types of impact-producing factors considered in this cumulative analysis include cumulative onshore impacts such as (1) wetland loss as a result of environmental degradation and natural factors, e.g., hurricane loss of wetlands; (2) marine environmental degradation including factors affecting marine hypoxia; and (3) physical disturbance of live-bottom features, including non-OCS-related disturbances such as those related to commercial and recreational fishing; (4) removal of production structures; (5) petroleum spills; (6) subsurface blowouts; (7) pipeline trenching; and (8) offshore discharges of drilling mud and produced waters. All of these subjects are discussed at length in Chapter 4.5.10 of the Multisale EIS and in Chapter 3 of the 2009-2012 Supplemental EIS.

Wetland Loss

The most serious impact to coastal EFH is the cumulative effects on wetlands that are occurring at an ever-increasing rate. This is from the population increase of the Gulf Coast States and the recent effects of major storms on wetland loss. The cumulative impacts of pipelines; canal dredging to accommodate commercial, residential, and recreational development; and major storm events (i.e., Hurricanes Katrina and Rita 2005; Hurricanes Gustav and Ike 2008) to wetlands are described in Chapter 4.5.3.2 of the Multisale EIS, in Chapter 4.1.3.2.4 of the 2009-2012 Supplemental EIS, and in **Chapter 4.1.1.4.4** of this Supplemental EIS.

In comparison to the large area of wetland loss to commercial and recreational development, as well as to natural forces such as hurricanes, the incremental wetland losses due to the CPA proposed action are anticipated to be minimal.

Marine/Estuarine Water Quality Degradation

The coastal waters of the CPA are expected to continue to experience nutrient overenrichment, periods of low-dissolved oxygen, and toxin and pesticide contamination. This results in the loss of both commercial and recreational uses of the affected waters. Fish kills and shellfish-ground closures would likely increase in numbers in the coming years. Localized, minor degradation of coastal water quality is expected from the proposed action within the immediate vicinity of the waterbodies proximate to the

proposed service bases, commercial waste-disposal facilities, and gas processing plants as a result of routine effluent discharges and runoff. Only a small amount of dredging would occur as a result of the CPA proposed action.

The incremental contribution of the CPA proposed action, because the input of effluent, runoff, and nutrients from such action is very limited, would be a very small part of the cumulative impacts to coastal water quality.

Damage to Live Bottoms

Non-OCS sources of impacts on biological resources and the structure of live bottoms include natural disturbances (e.g., turbidity, disease, and storms), anchoring by recreational and commercial vessels, and commercial and recreational fishing. These impacts may result in severe and permanent mechanical damage at various scales to live-bottom communities. Fishing activities that could impact live bottoms would include trawl fishing and trap fishing. These techniques and their impacts are described in detail in the Chapter 4.5.10 of the Multisale EIS.

The OCS-related activities that could impact the biological resources and the structure of live bottoms are the anchoring of vessels, emplacement of structures (drilling rigs, platforms, and pipelines), sedimentation (operational waste discharges, pipeline emplacement, explosive removal of platforms, and blowouts), and chemical contamination (produced water, operational waste discharges, and petroleum spills). Live-bottom features in the CPA consist primarily of the Pinnacle Trend, which is described in detail in Chapter 4.1.4.1.1 of the Multisale EIS. The Topographic Features Stipulation (in the CPA and WPA), enacted by this Agency and clarified in its NTL 2009-G39, would prevent most of the potential impacts on live-bottom communities and EFH from any OCS Program activities. These include bottom-disturbing activities (anchoring, structure emplacement and removal, and pipeline trenching), operational offshore waste discharges (drilling mud and cuttings and produced waters), and any nearby blowouts.

Because there are a large number of natural factors that can affect live bottoms and because the OCS factors that can affect live bottoms have been mitigated by BOEMRE, the OCS factors are anticipated to be a small portion of impacts to live bottom features in the CPA.

Structure Removals

Structure removals would result in artificial habitat loss. It is estimated that 30-42 structures would be removed as a result of the OCS Program in the CPA (**Table 3-2**). It is expected that structure removals would have an effect on fish resources near the removal sites when explosives are used (23-32 structures are expected to be removed by explosives, **Table 3-2**). However, only those fish proximate to sites removed by explosives would be killed. These expected impacts to fish resources have been shown to be small overall and would not alter determinations of status for impacted species or result in changes in management strategies (Gitschlag et al., 2000).

Petroleum Spills

Spills that contact coastal bays, estuaries, and offshore waters when pelagic eggs and larvae are present have the greatest potential to affect fish resources. If spills occur in these coastal environments or waters of the OCS that are proximate to mobile adult finfish or shellfish, the effects would likely be nonfatal. The extent of this damage would be reduced due to the capability of adult fish and shellfish to avoid a spill, to metabolize hydrocarbons, and to excrete both metabolites and parent compounds. For eggs and larvae contacted by spilled oil, the effect is expected to be lethal. The numbers and sizes of coastal spills over the 40-year life of the proposed action are presented in Table 4-13 of the Multisale EIS. About 90 percent of these spills are projected to be from non-OCS-related activity. For spills <1,000 bbl, the assumed size for an average spill is 5 bbl, so the great majority of coastal spills would affect a very small area and dissipate rapidly (Table 4-13 of the Multisale EIS). The small coastal spills that do occur from OCS-related activity would originate near terminal locations in the coastal zones of the CPA.

One large (≥1,000 bbl) offshore spill is projected to occur annually from the Gulfwide OCS Program (Table 4-13 of the Multisale EIS), and a total of 1,500-1,800 small offshore spills (<1,000 bbl) are projected annually. Of these, 450-500 would originate from OCS Program sources. Chapter 4.3.1.2 of the Multisale EIS describes projections of future spill events in more detail. The impacts of a catastrophic

spill, such as the DWH event, in the CPA are discussed in detail in **Appendix B** with the currently available data.

Because spills are a low-probability event, both in the inshore and the OCS area, the cumulative impact on EFH and fish populations in the CPA is not anticipated to be large as a result of the CPA proposed action.

Subsurface Blowouts

Subsurface gas blowouts of both oil and natural gas wells have the potential to affect adversely fishery resources. Loss of well control and resultant blowouts seldom occur on the Gulf of Mexico OCS. Considering the entire OCS Program during the 40-year analysis period, it is projected that there would be 169-197 blowouts out of 23,181-26,243 development wells (<1%) for all water depths in the CPA (Table 4-6 of the Multisale EIS).

Sandy sediments would be quickly redeposited within 400 m (1,312 ft) of a blowout site, and finer sediments would be widely dispersed and redeposited within a few thousand meters or feet over a period of 30 days or longer. These events are expected to have a negligible impact on fish populations. It is expected that the infrequent subsurface natural gas blowout that may occur on the Gulf of Mexico OCS would have a negligible effect on offshore fish resources.

Subsurface blowouts, such as the DWH event, that include both oil and natural gas have the potential to affect fish populations, particularly eggs, larvae, and juveniles. The specific effects of this type of spill on individual fish populations in the Gulf of Mexico are currently unknown. Spills from this type of a blowout are a low-probability event, so the cumulative impact on EFH and fish populations in the CPA is not anticipated to be large as a result of the proposed CPA lease sale.

Pipeline Trenching

Sediment would potentially be resuspended during the installation of pipelines. A total of 130-2,075 km (80-1,289 mi) of pipeline is projected to be installed in the CPA (only in the water depth category of <60 m or 200 ft) during the 40-year analysis period (**Table 3-2**). In many areas of the Gulf of Mexico, sediments are not static, as evidenced by the relatively recently discovered deep-sea furrows (Bryant et al., 2004).

Because the contribution of resuspended sediment as a result of pipeline trenching compared with the natural movement of sediment on the sea floor is very small, the effect on fish resources from pipeline trenching is expected to be minimal.

Discharges of Drilling Mud and Produced Waters

Drilling mud discharges contain chemicals toxic to marine fishes. These concentrations of toxins are four or five orders of magnitude higher than those found more than a few meters or feet from the discharge point. Offshore discharges of drilling mud dilute to near background levels within 1,000 m (3,280 ft) of the discharge point and would have a negligible effect on the fishery.

Produced-water discharges contain components and properties detrimental to fishery resources. These include petroleum hydrocarbons, trace metals, radionuclides, and brine. Limited petroleum concentrations and metal contamination of sediments and the upper water column would occur out to several hundred meters or feet down current from the discharge point. Offshore discharges of produced water disperse and dilute to near background levels within 1,000 m (3,280 ft) of the discharge point and have a negligible effect on fisheries. Offshore live bottoms would not be impacted. Offshore discharges and subsequent changes to marine water quality are regulated by USEPA NPDES permits.

Biomagnification of mercury in large fish of higher trophic levels is a problem in the Gulf of Mexico. In the press, biomagnification is often associated with drilling discharges, but the bioavailability and any association with trace concentrations of mercury in discharged drilling mud has not been demonstrated. Numerous studies have concluded that platforms do not contribute to higher mercury levels in marine organisms. Recent data suggest that mercury in sediment from drilling platforms is not in a bioavailable form (Trefry and Smith, 2003; Trefry et al., 2003).

The input of drilling mud and produced waters are limited and are diluted very quickly in the marine environment. Their environmental effects are, therefore, expected to be limited.

Summary and Conclusion

Activities resulting from the OCS Program and non-OCS events in the northern Gulf of Mexico have the potential to cause cumulative detrimental effects on fish resources and EFH. Impact-producing factors of the cumulative scenario that are expected to substantially affect fish resources and EFH include coastal and marine environmental degradation, overfishing, and to a lesser degree, coastal petroleum spills and coastal pipeline trenching. The implementation of proposed lease stipulations and mitigation policies that are currently in place, the small probability of an oil spill, and that flow regimes are not expected to change further reduce the incremental contribution of stress from the CPA proposed action on coastal habitats. The Live Bottom (Low Relief) Stipulation and the guidelines in NTL's 2009-G39 and 2009-G40 would limit the potential impact of any activities on deepwater EFH because the stipulation and NTL's keep the sources of such adverse events geographically removed from EFH. Decreases of impacts to EFH will decrease the impacts of similar activities on fish resources. At the estimated level of cumulative impact, the resultant influence on fish resources and EFH is expected to be substantial, but not easily distinguished from effects due to natural population variations.

The incremental contribution of the CPA proposed action to the cumulative impacts on fish resources and EFH is small, as analyzed in Chapters 4.2.2.1.10, 4.4.10, and 4.5.10 of the Multisale EIS. The effects of impact-producing factors (e.g., coastal and marine environmental degradation, petroleum spills, subsurface blowouts, pipeline trenching, and offshore discharges of drilling mud and produced waters) related to the CPA proposed action are expected to be negligible and virtually undetectable among the other cumulative impacts and natural population variability.

4.1.1.17. Commercial Fishing

The BOEMRE has reexamined the analysis for commercial fishing presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for commercial fishing presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. Routine activities in the CPA, such as seismic surveys and pipeline trenching, would cause negligible impacts and would not deleteriously affect commercial fishing activities. Indirect impacts from routine activities to inshore habitats are negligible and indistinguishable from direct impacts of inshore activities on commercial fisheries. The potential impacts from accidental events (i.e., a well blowout or an oil spill) associated with the CPA proposed action are anticipated to be minimal. Commercial fishermen are anticipated to avoid the area of a well blowout or an oil spill. Any impact on catch or value of catch would be insignificant compared with natural variability. The incremental contribution of the proposed action to the cumulative impacts on commercial fishing is small, and it is expected to be negligible and indiscernible from natural fishery population variability.

4.1.1.17.1. Description of the Affected Environment

Detailed descriptions of commercial fishing can be found in Chapter 3.3.1 of the Multisale EIS and in Chapter 4.1.12.1 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Finfish

Commercial fishing regulations are detailed and change on a regular basis depending on a variety of factors, including stock assessment and catch statistics. These regular changes, not withstanding any closures based on the DWH event, can occur on short notice. This is especially true for time closures based on allowable catches. The Gulf of Mexico Fishery Management Council (GMFMC) provides the

current information on commercial and recreational fishing rules for U.S. Federal waters of the GOM (GMFMC, 2010a and 2010b).

In September 2008, Hurricanes Gustav and Ike made landfall on the Gulf Coast. Hurricane Gustav came ashore southwest of New Orleans as a Category 2 storm, and Hurricane Ike made landfall as a Category 2 storm at Galveston, Texas. In April 2009, the Louisiana Dept. of Wildlife and Fisheries announced a $15.7 million cooperative research program with NOAA to monitor the recovery of Louisiana commercial fisheries impacted by Hurricanes Katrina, Rita, Gustav, and Ike (Louisiana Dept. of Wildlife and Fisheries, 2009). Caffey (personal communication, 2009) estimated revenue losses from Hurricanes Gustav and Ike on Louisiana fisheries and aquaculture sectors in excess of $98 million. The NOAA landings data show a drop in finfish and shrimp harvest in Louisiana (USDOC, NMFS, 2010c). This may be due to loss of boats and infrastructure.

In September 2008, the Louisiana Dept. of Wildlife and Fisheries (2008a and 2008b) released preliminary, nonquantitative reports of the effects of Hurricane Gustav on Louisiana fisheries. In it they noted the extensive marsh erosion and vegetative debris present in the canals of southeastern Louisiana. There was a loss of marsh through erosion and displacement and encroachment of saltwater into freshwater areas, which contributes to the loss of essential fish habitat, and localized fish kills.

Menhaden, with landings of over 1 billion pounds and valued at $60.5 million, was the most important Gulf species in terms of quantity landed during 2009. The menhaden catch was up from 927.5 million pounds worth $64.3 million in 2008 in the Gulf of Mexico, although the price per pound was down (USDOC, NMFS, 2010c). Data presented in the 2009-2012 Supplemental EIS clearly show that menhaden and shrimp are major fisheries in the Gulf of Mexico. Menhaden are harvested extensively for their oil, which is included in animal food and human supplements as Omega-3 fatty acid.

The DWH event changed the baseline of GOM commercial fishing, at least for the 2010 fishing season, because of the massive fishing closures associated with the event. This spill resulted in commercial fisheries closures in the GOM waters (EEZ) as well as State and inshore waters in Louisiana, Mississippi, Alabama, and Florida at various times during the spill. State commercial fishing areas changed with the movement of the oil. The closures were generally limited to the area between Vermilion Bay, Louisiana, and Pensacola, Florida.

The fishing closure area in the Gulf varied from 6,817 mi^2 (17,648 km^2) on May 2, 2010, when the closure was initiated to a high of 88,522 mi^2 (229,270 km^2), or 36 percent, of the EEZ on June 2, 2010. The closure area was located off the coasts of Louisiana, Mississippi, Alabama, and Florida based on projections of the path of the spilled oil. The closed area increased as the spill continued and spread (USDOC, NOAA, 2010i). On April 19, 2011, NOAA reopened to commercial and recreational fishing the last areas of the Gulf closed to fishing due to the DWH spill (USDOC, NOAA, 2011b).

The resulting impacts for the short- and long-term of the DWH event to commercial finfish species of the Gulf Coast are unknown at this time. Because nondispersed oil generally floats on the surface of water, the fisheries resources most at risk are those species whose eggs and larvae float near the water surface. Some species have spawning periods with narrow temporal peaks coinciding with the timing of the highest oil concentrations. These species could experience measurable effects on that area's year class. Early developmental stages are generally more susceptible to sublethal toxic effects, which may lead to abnormal development.

One important highly migratory species with a spawning period coinciding with the spill is the Atlantic bluefin tuna. This species has its peak spawning period in April and May in the Gulf (Teo et al., 2007a and 2007b). A catastrophic spill, such as the DWH event, during the spring season may cause a negative effect on this population. This is one of only two documented spawning grounds for the Atlantic bluefin tuna (the other is in the Mediterranean). Eggs are buoyant, which puts them at greater risk of floating oil. Bluefin tuna are among the most valuable fish in global markets. On September 21, 2010, NMFS announced a 90-day finding for a petition to list Atlantic bluefin tuna (*Thunnus thynnus*) as endangered or threatened under the Endangered Species Act and to designate critical habitat concurrently with the listing (*Federal Register*, 2010f). There may be many other commercially important species such as menhaden, red snapper, groupers, mackerel, swordfish, sheepshead, blacktip sharks, red drum, speckled trout, and many more that occur on the shelf or in estuarine waters that have been affected by the DWH event. Due to the lack of published/analyzed data, these effects are unknown at this time. The largest cash fishery in the Gulf Coast is menhaden. Menhaden are small schooling fish that are surface feeders, making them very vulnerable to the surface oil.

There have been some confirmed reports of inshore fish kills, particularly in Louisiana, Mississippi, and Alabama. Fish kills have been reported in inshore Louisiana behind the Chandeleur Islands, behind the rock jetties at the mouth of the Mississippi River Gulf Outlet, at Joshua's Marina south of Empire, in Bayou Chaland, and in Bay Joe Wise. Communications with Martin Bourgeois (written communication, 2010a) and Harry Blanchet (written communication, 2010) about these various kills between August 24 and September 24, 2010, confirm that most of the species that died were menhaden in high-temperature, low dissolved oxygen waters. This is not unusual during the summer in the shallow, high-temperature, low dissolved oxygen waters of Louisiana that contain large concentrations of fish. It is impossible, however, to discount completely that the oil spill contributed to the oxygen depletion of these waters. While this is a somewhat common occurrence, oil cannot be ruled out as a factor contributing to low dissolved oxygen. Fish kills in Louisiana and Mississippi are summarized in **Table 4-7**. Personnel from the Alabama Dept. of Environmental Monitoring confirmed that there had been some fish kills in Mobile Bay, all of which had been attributed to low dissolved oxygen and high temperatures (Denson, personal communication, 2010).

Shellfish

Commercial shellfish of most importance to the central Gulf Coast include shrimp (primarily brown and white), blue crabs, and oysters. In 2009, the central Gulf States harvested a total of nearly 56.1 million pounds of brown shrimp and over 90.6 million pounds of white shrimp. This constitutes approximately 44 percent and 73 percent of the brown and white shrimp, respectively, harvested in the entire U.S. Blue crab harvest in the three central Gulf States was approximately 53.0 million pounds in 2009, or about 35 percent of the total U.S. harvest. Eastern oyster (*Crassostera virginica*) harvest in Louisiana, Mississippi, and Alabama in 2009 totaled 16.9 million pounds of oyster meat or approximately 68.4 percent of all the Eastern oyster meats harvested in the U.S. for that year. Louisiana alone harvested 14.7 million pounds of oyster meats, or 59.5 percent of all of the Eastern oyster meats harvested in the U.S. in 2009.

The commercially important species of shrimp (particularly the white and brown shrimp of Louisiana and Mississippi) and blue crabs spend at least part of their life cycle in the estuaries or on the nearshore shelf. Both shrimp species and the blue crab spawn in high salinity waters offshore, and the larvae and subadults move inshore to mature in the estuaries of the coast. These species are short lived, and losses to the crop from the DWH event may be evident in the 2011 harvest if they are not offset by the fishing closures.

Eastern oyster grounds are located in the CPA from Sabine and Calcasieu Lakes eastward in the inshore bays and estuaries of Louisiana, through eastern Mississippi Sound (Mississippi), Mobile Bay (Alabama), and from upper Pensacola Bay through Apalachicola Bay (Florida). Public seed grounds in Louisiana include Calcasieu and Sabine Lakes, Bay Gardene, Hackberry Bay, Sister Lake, Bay Junop, Lake Borgne, Breton/Chandeleur Sound, Barataria Bay, Little Lake, Deep Lake, Lake Chien, Lake Felicity, Lake Tambour, Lake Mechant, and Vermilion/Cote Blanche and Atchafalaya Bays (Louisiana Dept. of Wildlife and Fisheries, 2010a). These seed grounds provide a source of spat (small oysters) for oystermen to transplant to their leases for grow-out, as well as a source of sack-sized oysters that can be readily marketed. Every July, the Louisiana Dept. of Wildlife and Fisheries conducts a survey of thee public seed grounds. The general trend of oyster abundance on the seed grounds has been decreasing since 2001, approaching the 2nd smallest statewide stock size since 1989. According to the 2010 assessment, the 2010 stock size showed an overall slight increase over the 2009 stock size (Louisiana Dept. of Wildlife and Fisheries, 2010a).

The DWH event may have an effect on this year's crop, but it is difficult to infer with the current lack of public data. Many of the beds have been closed for most of the season. The public seed ground openings for much of the area east of the Mississippi River and Hackberry Bay west of the Mississippi River that were scheduled for November 15, 2010, have been postponed indefinitely because of the small size of the stock present in that area. Although the small stock size has not been directly attributed to the spill, it may be a result of the freshwater diversions that were operated in an attempt to keep oil from reaching the inshore areas.

The larval and juvenile stages of aquatic organisms are more vulnerable to contact with hydrocarbons than adults (Moore and Dwyer, 1974). Contact with oil does not always kill adult oysters, a fact

demonstrated by Mackin and Sparks (1961), but it does affect their taste and render them unmarketable. Oysters will clear themselves of the taste given clean water conditions. If, however, the oil is combined with other stress factors, such as extreme temperatures and low salinities, death may result. In an attempt to keep the oil out of the inshore areas of Louisiana, the freshwater diversions were run at near maximum capacity. Sustained freshwater kills oysters, especially at high temperatures (Davis, 1958). The higher the temperature and the lower the salinity, the shorter the oyster life will be.

Representatives of the Louisiana Dept. of Wildlife and Fisheries confirmed that there had been a complaint of an oyster kill in Bay Jacques in Plaquemines Parish, Louisiana, on June 20, 2010 (Bourgeois, personal communication, 2010b). The report reads as follows:

> They saw approximately 100 floating pieces of oysters (more were seen coming from the prop wash so likely more dead ones on the bottom), but it is nearly impossible to estimate. Coordinates in decimal degrees—N29.28725 W89.51665, coordinates in decimal minutes—N29°17.235' W89°30.999'. There are fish swimming in the area and no dead fish were seen. The surface DO was 10.2 mg/L, pH was 8.7, temp was 32.9°C, and salinity was 0.9 ppt. Bottom DO was 10.1 mg/L, pH was 8.7, temp was 32.9°C, and salinity was 0.9 ppt. Low salinity and high temperature combined appear to be responsible for this kill although other factors cannot be excluded.

Mississippi Sound and Alabama oyster beds were closed to oyster fishing for approximately 2 months during the summer of 2010. There are several areas of oyster reefs in the panhandle of Florida: Pensacola, Choctawhatchee, St. Andrew, and Apalachicola. The primary producing area is Apalachicola Bay. None of the Florida Panhandle reefs areas were closed as a result of the spill.

Stock Status

The NOAA Fisheries reports to the Congress and Fishery Management Councils on the status of all fish stocks in the Nation. As of the 2008 status report (USDOC, NMFS, 2008), they reviewed 531 individual stocks and stock complexes and made determinations of overfishing and overfished for 191 complexes; an additional 68 stocks have either an overfishing or overfished determination. Overfishing is harvesting at a rate above a prescribed fishing mortality threshold, and overfished is defined as a stock size that is below a prescribed biomass threshold. Species that are currently listed as subject to overfishing in the GOM are red snapper, greater amberjack, gag grouper, gray triggerfish, and pink shrimp. Overfished species in the GOM are red snapper, greater amberjack, and gray triggerfish. The effects of the DWH event on the population levels of each of these species are unknown at this time.

Economics of Commercial Fisheries

The commercial fishing industry is an important component to the economy of the Gulf of Mexico. **Table 4-8** provides an overview of the economic significance of the commercial fishing industry in the Gulf of Mexico (USDOC, NMFS, 2010d). Commercial fishing landings in the Gulf were worth over $700 million in 2008. Louisiana had the highest catch value with over $270 million, Texas and Florida each had around $170 million in landings, and Alabama and Mississippi each had around $40 million in landings. Detailed information regarding the catch rates and prices paid for individual species in each Gulf Coast State can be obtained through NMFS's economics report (USDOC, NMFS, 2010d). Further information on fishing harvests at individual Gulf Coast ports is also available.

Landings revenue also supports economic activity along the commercial fishing supply chain. **Table 4-8** presents estimates of sales and employment in the economy that depend on commercial fishing activity. Approximately $10 billion in combined sales activity and over 200,000 jobs depend directly or indirectly on commercial fishing in the GOM. Of the Gulf Coast States, Florida has the highest level of overall commercial fishing-dependent jobs due to a large number of retail outlets and seafood distributors located in the state. Louisiana has approximately 40,000 jobs in the industry, while Alabama and Mississippi each have slightly under 10,000 jobs. More detailed breakdowns of sales and employment statistics in each Gulf Coast State can be obtained through NMFS. The final column of **Table 4-8** presents the commercial fishing quotient, which is a measure of the concentration of the fishing industry

in a particular state relative to the national average. Louisiana has the highest commercial fishing quotient in the Gulf of Mexico; its commercial fishing quotient of 2.5 means that the concentration of the fishing industry in Louisiana is 2.5 times that of the U.S. average. Texas and Alabama have the lowest commercial fishing quotients in the Gulf; the concentration of the commercial fishing industry in these states is roughly one-third the national average.

The DWH event has had a number of effects on the commercial fishing industry. The most direct manner in which the spill affects the industry is through the potential for decreased harvests of a number of species over the next few years. While, at this time, there exists substantial uncertainty regarding the range and magnitude of these effects, IEM (2010) attempts to create estimates of the economic effects of lower harvests on the economy of the Louisiana. This study first estimates harvest losses of certain species over the next 3 years. It then uses available price information to compute a range of possible revenue losses for the industry. It estimates that revenue losses in Louisiana could be between $115 million and $173 million over the next 3 years. The IEM also attempts to estimate the broader economic implications from these potential revenue losses. Namely, losses in fishing harvests cause reduced revenue throughout the commercial fishing supply chain. In turn, this lower revenue reduces the income of workers in the commercial fishing industry, which reduces their spending on a broader range of goods and services. Based on this "multiplier" effect, IEM estimates that total output losses resulting from these effects could be between $285 million and $427 million over the next 3 years.

The DWH event has also affected the financial condition of the workers and firms who work in the commercial fishing industry. A number of workers were idled during the spill and during the subsequent State and Federal commercial fishing bans. Some of these workers were hired by BP as part of the Vessel of Opportunity program. While this work led to reasonably high income to some workers, it created a divergence among the financial conditions between those who were hired by the program and those who were not (Davidson, 2010). In addition, even though some fishermen were helped by the Vessel of Opportunity program, businesses further up the supply chain had fewer alternative options and thus suffered due to the closures. Payments from BP also helped mitigate the financial damage to some individuals and businesses to some extent; as of November 27, 2010, $124 million in damage claims had been paid to individuals and $354 million had been paid to firms in the fishing industry in the GOM (Gulf Coast Claims Facility, 2010a).

The long-term economic implications of the DWH event on the commercial fishing industry remain unclear. In part this is due to uncertainty regarding the fate of fish species in the GOM. However, it will also take some time to determine the speed and extent to which confidence in the seafood industry in the GOM will be restored. Preliminary evidence suggests that the general public became wary of consuming seafood from the Gulf of Mexico as the spill progressed. For example, Louisiana State University and the University of Minnesota conducted a nationwide survey of roughly 1,000 people to gauge the effects of the spill on seafood consumption. This study found that one-half of the overall population was extremely concerned about the effects of the spill on seafood and that a one-third of the population would curtail their overall seafood consumption to some extent. It is likely that confidence in the seafood industry will gradually return if Gulf seafood can be demonstrated to be safe. Indeed, BP has given Louisiana $18 million for seafood monitoring and $30 million for seafood promotion programs (World Fishing Network, 2010). The Federal Government also has programs in place to monitor the safety of seafood obtained from reopened fishing areas. Information regarding these testing programs and their findings can be found at the U.S. Dept. of Health and Human Services, Food and Drug Administration (2011) and USDOC, NOAA (2011b). These testing programs have generally found that seafood from Gulf waters is safe. However, Wilkinson (2011) provides a summary of some of the longer term concerns regarding the impacts of the oil spill on the fishing industry in the Gulf of Mexico. However, it will take some time before the full impacts of the oil spill, including actual fisheries impacts and the effects of perceptions on seafood consumption, are fully understood.

4.1.1.17.2. Impacts of Routine Events

Background/Introduction

The detailed description of possible impacts on commercial fishing from routine activities associated with the CPA proposed action is given in Chapter 4.2.2.1.11 of the Multisale EIS and in Chapter 4.1.12.2 of the 2009-2012 Supplemental EIS. The BOEMRE has reexamined the impacts of CPA activities on the

commercial fisheries resources. A search was conducted for new information published since completion of the Multisale EIS and the 2009-2012 Supplemental EIS. A search of Internet information sources (including scientific journals), as well as interviews with personnel from academic institutions and governmental resource agencies, was conducted to determine the availability of new information. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Direct effects on commercial fishing from routine offshore activities could result from the installation of production platforms, underwater OCS obstructions including pipelines, production platform removals, seismic surveys, and the discharge of offshore waste.

Offshore structures can cause space-use conflicts with commercial fishing, especially with longline fishing. Exploratory drilling rigs cause temporary interference to commercial fishing, lasting approximately 30-150 days. Major production platforms present a permanent area unavailable for fishing that includes structures and safety zones. Underwater OCS obstructions such as pipelines can cause loss of trawls and catch, as well as fishing downtime and vessel damage.

Production platform removal in water depths <200 ft (61 m) removes artificial reef habitat and often involves the use of explosives. This is lethal to fish that have internal air chambers (swim bladders), are demersal, and are in close association with the structure or are transitory in the area. Intense sounds generated by seismic surveys affect the spatial distribution of fish during and for some period following exposure.

The most commonly discharged offshore wastes are drill mud and produced water. Drill mud contains metals such as mercury and cadmium, which are toxic to fishery resources. Produced water commonly contains brine, trace metals, hydrocarbons, organic acids, and radionuclides. Any or all of these constituents, in high enough concentrations, can be toxic to fish at any stage of their life cycle. Additionally, routine offshore activities may impact inshore commercial fisheries indirectly. These activities include the construction or expansion of onshore facilities in wetland areas, pipeline emplacement in wetland areas, vessel usage of navigation channels and access canals, maintenance of navigation channels, and inshore disposal of OCS-generated, petroleum-field wastes.

Degradation of coastal water quality may indirectly impact commercial fisheries. Coastal water quality (discussed at length in Chapter 4.2.2.1.2.1 of the Multisale EIS and in Chapter 4.1.2.1.2 of the 2009-2012 Supplemental EIS) may be affected adversely by saltwater intrusion and sediment disturbances from channel maintenance dredging, onshore pipeline emplacements, and canal widening. These factors potentially also affect the quality and quantity of wetlands and the quality of estuaries. Many commercial fish in the offshore Gulf of Mexico depend on these resources as nursery habitat. Trash, discharges, and runoff may be released from onshore facilities and vessel traffic, and may cause degradation of coastal water quality. Besides coastal sources, trash occurring in association with OCS operations and reaching coastal waters may impact water quality conditions. Marine environmental degradation resulting from routine offshore activities also has the potential to indirectly affect commercial fish resources by reducing food stocks in soft-bottom and reef habitats. These routine activities include the offshore discharge of produced water and drilling mud.

Proposed Action Analysis

The routine activities associated with the CPA proposed action that would impact commercial fisheries include installation of production platforms, underwater OCS obstructions, pipeline trenching, production platform removals, seismic surveys, and the discharge of offshore waste.

The number of production structures projected as a result of the CPA proposed action range from 32 to 44. Applying a 500-m (1,640-ft) safety zone around a platform would exclude approximately 193 ac (78 ha) from commercial fishing, assuming that the operator applied to USCG for a safety zone around the platform. The total number of platforms projected in the CPA in <200 m (656 ft), the area in which concentrated bottom trawling occurs, is 20-25, thus potentially excluding 1,562-1,953 ha (3,860-4,825 ac) or <0.01 percent from the total area available to trawling.

Commercial fisheries conflicts with platforms in water deeper than 200 m (656 ft) are limited to the longline fishery. Surface-drifting longlines may contact a deepwater platform if not set an appropriate distance from the surface-piercing structure. The area of a surface-piercing structure is very small in relation to the total area available to longliners.

The number of kilometers of pipeline projected to be emplaced in the CPA in water depths <60 m (200 ft) is from 50 to 850 km (31 to 528 mi). In water depths >60 m (200 ft), the projected length of pipeline is unavailable. Because of pipeline burial requirements, it is assumed that installed pipelines would seldom conflict with bottom trawling activities in water depths <60 m (200 ft), and it would not conflict with commercial fishing in deeper waters.

Structural removals in water depths <200 m (656 ft) result in a loss of artificial habitat and in fish mortality when explosives are used. It is projected that 20-26 removals would result in the CPA in water depths <200 m (656 ft) as a result of the proposed action, making approximately 1,562-2,030 ha (3,860-5,018 ac) available again for commercial fishing. It is expected that structure removals would have a negligible impact on commercial fishing because of the small number of removals and the consideration that removals kill primarily those fish associated with the platforms or those transient in the area.

Produced water and drill mud are discharged in shallow and deep waters of the CPA. Studies of drill mud and produced water from platforms show that the plume disperses rapidly in both cases and does not pose a threat to commercial fisheries. In a recent study of the concentrations of the bioavailable form of mercury (methylmercury) in drill mud, Trefry et al. (2003) found concentrations did not vary significantly between near-platform and far-platform sites. Further, the study suggested that elevated levels of methylmercury in sediments around drilling sites are not a widespread phenomenon in the Gulf of Mexico (Trefry et al., 2003).

Summary and Conclusion

Routine activities such as seismic surveys and pipeline trenching in the CPA would cause negligible impacts and would not deleteriously affect commercial fishing activities. Because seismic surveys are temporary events, they are not expected to cause long-term or permanent displacement of any listed species from critical/preferred habitat or to result in the destruction or adverse modification of critical habitat or EFH. Operations such as production platform emplacement, underwater OCS impediments, and explosive platform removal would cause slightly greater impacts on commercial fishing, but their effects are localized to a small percentage of the area fished and they are temporary in nature.

Commercial catches by species and by State have been updated in **Chapter 4.1.1.17.1**, as have the impacts of the 2005 and 2008 hurricanes on fish and fish habitat from recent reports (USDOC, NMFS, 2010c; Haby et al., 2009). The new information presented in this Supplemental EIS does not alter the conclusion presented in the Multisale EIS and the 2009-2012 Supplemental EIS that impacts on commercial fisheries from routine activities associated with the CPA proposed action would be minimal.

4.1.1.17.3. Impacts of Accidental Events

Background/Introduction

The description of possible impacts on commercial fisheries resulting from accidental events associated with the CPA action is presented in detail in Chapter 4.4.10 of the Multisale EIS and in Chapter 4.1.12.3 of the 2009-2012 Supplemental EIS. The risk of oil-spill events as a result of the proposed action was discussed at length in Chapter 4.3.1 of the Multisale EIS, and the potential effects of a spill on commercial fisheries is detailed at length in Chapter 4.4.10 of the Multisale EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Accidental events that would impact commercial fisheries include subsurface offshore blowouts and oil spills, both inshore and offshore. There is a small risk of spills occurring during shore-based support activities. The great majority of these would be very small. Most of these incidents would occur at or near pipeline terminals or shore bases, and they are expected to affect a highly localized area with low-level impacts.

Proposed Action Analysis

The accidental events that would impact commercial fisheries include well blowouts, primarily gas well blowouts, and/or oil spills. Impacts of gas well blowouts on commercial fisheries are generally very localized and limited. Sediment redistribution would affect only the area within a few hundred yards of

the blowout. Impacts of oil or oil/gas mixture blowouts may affect commercial fisheries populations, depending on their exposure to the oil, the type of oil, and the time of year of the spill. Most commercial species are only affected if the oil reaches the shelf or the inshore estuarine waters.

Commercial fishermen would actively avoid the area of a small spill, but they may be prevented from fishing by State or Federal agency closures in some areas in the case of larger spills. Fish flesh tainting (oily tasting fish/shellfish) and resultant area closure could decrease commercial landings, value, or catch in the short term. Perception of tainting of commercial catches may affect the ability of commercial fishermen to sell their product.

Closure areas imposed by State or Federal agencies may also impact the commercial fisheries positively in the long term by easing fishing pressure on commercially (especially annually) harvested populations.

The effects of the DWH event on commercial fisheries are preliminary and mostly speculative. Data are lacking, and it will take several years to analyze specific long-term effects of the DWH event on all Gulf of Mexico commercial fisheries populations.

Blowout and Oil-Spill Impacts

A subsurface blowout event, although highly unlikely, has the potential to affect fish within a few hundred feet of the blowout. A blowout at the seafloor can cause a crater that might interfere with longlining in the near vicinity or cause an area to be closed to longlining. A seafloor blowout could also result in a localized increase in suspended sediments. These sediments can clog finfish gills and interfere with respiration. Sediments remaining in suspension can cause interference in feeding in finfish species that are sight feeders. Coarse sediments such as sand-sized particles, however, fall out of the water column quickly, but finer sediments are redistributed by currents and settle out over a larger area.

Oil spills may occur from blowouts; however, most product loss from blowouts is natural gas, primarily methane, which rapidly dissolves in the water column or escapes into the air. Recently published research (Kessler et al., 2011) revealed that a large amount of methane was released by the DWH event and, based upon the methane and oxygen distributions measured at 207 stations in the affected area, a large amount of oxygen was respired by methanotrophs. Kessler et al. suggest that the methane triggered a large methanotroph bloom that rapidly degraded the methane, leaving behind a residual methanotrophic community.

Most of the commercial fish and shellfish harvested in the CPA are estuarine dependent at some point in their life cycles. These include brown shrimp, white shrimp, pink shrimp, blue crabs, croaker, sheepshead, menhaden, black drum, red drum, spotted sea trout and sand sea trout. Oysters are most abundant in estuarine areas. Other species such as red snapper and king mackerel are most abundant on the shelf.

Oil spilled in the offshore areas is usually localized and has a very low probability of reaching shelf waters and coastal estuaries. Much of the oil volatilizes or is dispersed by currents in the offshore environment. Oil that is not volatilized, dispersed, or emulsified by dispersants, and through a combination of oceanographic and meteorological factors moves onto the shelf or into the estuaries and has the potential to affect finfish through direct ingestion of hydrocarbons or ingestion of contaminated prey. Hydrocarbon uptake of prey can be by dissolved petroleum products through the gills and epithelium of adults and juveniles, decreased survival of larvae, and death of eggs (NRC, 1985 and 2002a). All of these mechanisms are discussed at length in Chapter 4.4.10 of the Multisale EIS.

Actual effects of any oil that is released and comes in contact with the shelf or estuarine populations of commercially important species will depend on the API gravity of the oil, its ability to be metabolized by microorganisms, and the time of year of the spill. Effects on the populations would be at a maximum during the spawning season of any commercially important population, exposing larvae and juvenile to oil. Effects on commercial species may also include tainting of flesh or the perception of tainting in the market. This can, depending on the extent and duration of the spill, affect marketability of commercial species.

The effects on future generations of commercial fisheries depend on the mobility of the species and the length of their life cycles. Sessile species such as oysters would be affected more than species with the ability to avoid the oil. Species with short life cycles such as shrimp and crabs are most vulnerable because they are essentially an annual crop. Longer-lived species such as snapper and grouper have more

resilience because these populations consist of multiple year classes that can breed, and the failure of any one year class does not necessarily threaten the survival of the population.

Closure areas imposed by State or Federal agencies may impact the commercial fisheries of an area either inshore in State waters or in the EEZ by easing fishing pressure on commercially harvested populations. Most of these short-lived, estuarine-dependent species, such as brown and white shrimp and blue crabs, are harvested on an annual basis. Closure to harvest relieves the annual fishing pressure and, assuming no devastation of the population due to the effects of oil, may actually increase population levels during the period of closure.

Recent data collected by Dauphin Island Sea Lab researchers from stations outside of the barrier islands and inside of the estuaries prior to and after the DWH event and resulting spill show a clear increase in biomass and abundance of estuarine species such as Atlantic croaker, spot, shrimp, and crabs (i.e., post-DWH spill). Species studied were most abundant in the estuaries (as compared with outer barrier island stations) both pre-and post-spill. These data also show that the ratio between the total abundance of shrimp and crabs to Atlantic croaker and spot exhibited a huge decrease in the ratio after the spill (Valentine, personal communication, 2010). Area closure may, therefore, have a positive impact on inshore commercial fisheries populations.

Information on the effects of the DWH event on commercial fisheries is preliminary. Data are lacking and it will take several years to analyze the effects of this event on all Gulf of Mexico commercial fisheries populations.

Summary and Conclusion

The BOEMRE has reexamined the analysis for impacts to commercial fish resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on updated information obtained through the peer reviewed data, Internet sources, and conversations with Gulf Coast State agencies, Federal agencies, and professors at local academic institutions. No substantial newly published, peer-reviewed information was found that would alter the overall conclusion that impacts to commercial fish resources from accidental activities associated with the CPA proposed action would be minimal. In summary, the impacts of the CPA proposed action from accidental events (i.e., a well blowout or an oil spill) are anticipated to be minimal because the potential for oil spills is very low.

Fish populations may be impacted by an oil-spill event should it occur, but they would be primarily affected if the oil reaches the productive shelf and estuarine areas. The probability of an offshore spill impacting these nearshore environments is also low, and oil would generally be volatilized or dispersed by currents in the offshore environment. Extent of the impacts of the oil would depend on the properties of the oil and the time of year of the event.

Commercial fishermen are anticipated to avoid the area of a well blowout or an oil spill. Fisheries closures may result from a large spill event. These closures may have a negative effect on short term fisheries catch and/or marketability. In the long term, they may have a positive impact on annually harvested species because there was a decrease in fishing pressure on the stocks.

4.1.1.17.4. Cumulative Impacts

Background/Introduction

A detailed description of cumulative impacts on commercial fishing can be found in Chapter 4.5.11 of the Multisale EIS and in Chapter 4.1.12.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared. This information has been gathered from referenced journals, government agency publications, conversations with government resource agency employees, and the Internet.

Specific types of impact-producing factors considered in the cumulative analysis include the following: (1) commercial fishing techniques or practices; (2) hurricanes; (3) installation of production platforms and underwater OCS obstructions; (4) production platform removals; (5) seismic surveys; (6) petroleum spills; (7) subsurface blowouts; (8) pipeline trenching; and (9) offshore discharges of drilling mud and produced waters.

Commercial Fishing Practices

There is competition among large numbers of commercial fishermen, among commercial operations employing different fishing methods, and between commercial and recreational fishermen for a given fishery resource. That competition, coupled with natural phenomena such as hurricanes, hypoxia, and red or brown tides, can impact commercial fishing activities. When practiced nonselectively, fishing techniques such as trawling, gill netting, or purse seining may reduce the standing stocks of the desired target species. This can also significantly affect species other than the target. In addition, continued fishing of most commercial species at the present levels can result in rapid declines in the landings and the eventual failure of certain fisheries.

Hurricanes

Hurricanes may impact commercial fishing by damaging gear and shore facilities and by dispersing resources over a wide geographic area. Hurricanes may also affect the availability and price of key supplies and services (e.g., fuel) that also affect commercial fishing. Hurricanes suspend fishing activity and are destructive to wetlands that act as nursery grounds to many commercial fish. Hurricanes can be extremely destructive to oyster beds by causing siltation over the beds and smothering spat along with adult oysters, as evidenced by Hurricanes Katrina, Rita, Gustav, and Ike. Commercial fisheries landings of the central Gulf Coast were drastically impacted by Hurricanes Katrina and Rita in 2005 as a result of the severe impact on coastal port facilities and fishing vessels. These data are discussed in detail in Chapter 3.3.1 of the Multisale EIS. Equally as destructive were Hurricanes Gustav and Ike in 2008, as discussed in **Chapter 3.3.7.2** of this Supplemental EIS. These impacts were so severe that Commerce Secretary Gutierrez determined a fisheries resource disaster as a result (Upton, 2010). However, natural disaster impacts such as these are easily distinguished from incremental impacts of OCS activities.

Installation of Production Platforms and Underwater Obstructions

The CPA proposed action is anticipated to result in the installation of 32-44 new production facilities (**Table 3-2**). These productions facilities compete with commercial fishing interests for physical space in the open ocean. The facilities can also be associated with underwater OCS obstructions that pose hazards to fishing nets. These facilities are also known fish attracting devices, so fish often congregate around them for food and shelter from predators. The area occupied by these structures is small compared with the area available in the CPA for fishing. Because the area is small, the cumulative impact of the CPA proposed action to the commercial fisheries of the CPA is anticipated to be small.

Platform Removals

Offsetting the anticipated installation of platforms in the CPA is the anticipated removal of 30-42 existing platforms (**Table 3-2**). The removal of these platforms not only frees the area for commercial fishing but also removes them as fish attracting devices. There is the possibility the structures can be used in a rigs-to-reef program where they would serve as artificial habitat for fish. Of those estimated to be removed, 23-32 are anticipated to be removed using explosives (**Table 3-2**). Explosives do cause mortality in fish with swim bladders when they are either associated with the platform or transient in the area at the time of the explosions. Because the number of platform removals is small, the effects on commercial fishery populations are expected to be minimal.

Seismic Surveys

Seismic surveys are used in both shallow- and deepwater areas of the Gulf of Mexico. Although it has been alleged that catch rates are lower after seismic surveys, fishermen are usually precluded from the area for several days. This should not significantly affect the annual landings or the value of landings for commercial fisheries because Gulf of Mexico species are found in many adjacent locations and Gulf commercial fishermen do not fish in one locale.

Petroleum Spills

The potential causes, sizes, and probabilities of petroleum spills that could occur during activities associated with the CPA proposed action are discussed in detail in **Chapter 3.2.1**. One large (≥1,000 bbl) offshore spill is estimated to occur annually from all sources Gulfwide (Chapter 4.3.1.5.1 of the Multisale EIS). Large spills can potentially affect commercial fisheries resources by causing potential losses to commercial fish populations. These potential population losses may be offset by commercial fisheries closure areas necessitated by a large spill. The effects of a catastrophic spill such as the DWH event, although based on limited data at this time, are discussed in **Appendix B**. Although the effects can be significant from any one spill, the overall probability of a large spill occurring is still low.

The majority of coastal spills in the Gulf (90%) are expected to be small (<1 bbl) and to cause a minimal decrease in commercial fishing local to the spill area. Because these spills are small, the resultant influence on commercial fishing, landings, or the value of those landings is not expected to be distinguishable from natural population variations.

Subsurface Blowouts

Subsurface blowouts of both oil and natural gas wells and pipeline trenching have the potential to adversely affect commercial fishery resources. The loss of well control and resultant blowouts seldom occur in the Gulf OCS over a 40-year time period (169-197 blowouts out of 28,191-32,832 wells drilled; i.e., <1%) (Table 4-6 of the Multisale EIS). Sandy sediments are quickly redeposited within 400 m (1,312 ft) of a blowout site, and finer sediments are widely dispersed and redeposited within a few thousand meters or feet over a period of 30 days or longer. These events are expected to have a negligible impact on fish populations. It is expected that the infrequent subsurface natural gas blowout that can occur on the Gulf of Mexico OCS would have a negligible effect on commercial fish resources.

Subsurface blowouts, such as the DWH event, that include both oil and natural gas have the potential to affect fish populations particularly eggs, larvae, and juveniles. The specific effects of this type of spill on individual fish populations in the Gulf of Mexico are currently unknown, and spills of this type are a low-probability event. Because these spills are a low-probability event, the contribution to the cumulative impact on commercial fisheries populations is not expected to be large as a result of the CPA proposed action.

Pipeline Trenching

Pipeline trenching also has the potential to affect commercial fisheries as a result of sediment suspension. Sandy sediments from either source are quickly redeposited within 400 m (1,312 ft) of the trench, and finer sediments are widely dispersed and redeposited over a period of hours to days within a few thousand meters of the event. No significant effects to commercial fisheries are anticipated as a result of oil or gas well blowouts or pipeline trenching. Resuspension of vast amounts of sediments as a result of large storms and hurricanes occurs on a regular basis in the northern Gulf of Mexico (<50 m; 164 ft) (Hu and Muller-Karger, 2007). In many areas of the Gulf of Mexico, sediments are not static under natural conditions, as evidenced by the recently discovered deep-sea furrows (Bryant et al., 2004).

The cumulative effect on commercial fisheries from oil and gas well blowouts in the Gulf OCS and pipeline trenching is not expected to be distinguishable from natural events or natural population variations.

Offshore Discharge of Drilling Mud and Produced Waters

Drilling mud discharges contain chemicals toxic to marine fishes, including brine, hydrocarbons, radionuclides, and metals. These concentrations are many orders of magnitude higher than those found more than a few meters or feet from the discharge point. Offshore discharges of drilling mud dilute to near background levels within 1,000 m (3,281 ft) of the discharge point and would have a negligible cumulative effect on fisheries.

Produced-water discharges contain components and properties detrimental to commercial fishery resources. Offshore discharges of produced water also disperses and dilutes to near background levels within 1,000 m (3,281 ft) of the discharge point and have a negligible cumulative effect on fisheries.

Offshore live bottoms would not be impacted. Offshore discharges and subsequent changes to marine water quality are regulated by USEPA NPDES permits.

Biomagnification of mercury in large fish of higher trophic levels is a problem in the Gulf of Mexico. In the press, this biomagnification is often associated with drilling discharges, but the bioavailability and any association with trace concentrations of mercury in discharged drilling mud has not been demonstrated. Numerous studies have concluded that platforms do not contribute to higher mercury levels in marine organisms. Recent data suggest that mercury in sediments near drilling platforms is not in a bioavailable form.

The input of drilling mud and produced waters are limited and are diluted very quickly in the marine environment. Their environmental effects are, therefore, expected to be limited.

Summary and Conclusion

Activities resulting from the OCS Program and non-OCS events have the potential to cause limited detrimental effects to commercial fishing, landings, and the value of those landings. The impact-producing factors of the cumulative scenario that are expected to substantially affect commercial fishing include commercial fishing techniques or practices, hurricanes, installation of production platforms and underwater OCS obstructions, production platform removals, seismic surveys, petroleum spills, subsurface blowouts, pipeline trenching, and offshore discharges of drilling mud and produced waters.

Recent substantial impacts occurred to commercial fisheries because of the 2005 and 2008 hurricanes. At the estimated level of cumulative impact, the resultant influence on commercial fishing, landings, and the value of those landings is expected to be substantial and easily distinguished from effects due to natural population variations. The effects of impact-producing factors (e.g., installation of production platforms, underwater OCS obstructions, production platform removals, seismic surveys, oil spills, subsurface blowouts, pipeline trenching, and offshore discharges of drilling mud and produced waters) related to the CPA proposed action are expected to be negligible and indiscernible from natural fishery population variability. This is because the installation of production platforms and underwater OCS obstructions in the area is small, the number of platform removals is small, seismic surveys are temporary, oil spills are vernally small scale, blowouts have a small probability, and trenching and discharges are highly regulated. The impacts of a catastrophic oil spill, such as the DWH event recently experienced in the Gulf of Mexico, based on limited data now available, are discussed in **Appendix B**.

4.1.1.18. Recreational Fishing

The BOEMRE has reexamined the analysis for recreational fishing presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. While the DWH event had some impacts on recreational fishing activity, the fact that the spill was a low-probability event leads the conclusions reached in the Multisale EIS and the 2009-2012 Supplemental EIS to be largely unchanged. Namely, the CPA proposed action could cause minor space-use conflicts and could have minor effects on fish populations that support recreational fishing activity. However, routine OCS activities can also enhance recreational fishing opportunities since oil platforms serve as artificial reefs for fish habitats. Small to medium spills are unlikely to significantly impact recreational fishing activity due to the short-term duration of their impacts and the likely availability of substitute fishing sites in a particular region. A large spill such as the DWH event can have more noticeable impacts to recreational fishing activity, as well as to individuals and firms that depend on angler spending. However, these effects can be mitigated to some extent through financial compensation and through policies of Federal and State fisheries management agencies. The CPA proposed action should not have large effects on recreational fishing activity since it does not significantly increase the likelihood of an additional spill along the lines of the DWH event.

4.1.1.18.1. Description of the Affected Environment

A detailed description of recreational fishing can be found in Chapter 3.3.3 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.14 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational fishing incorporated from the Multisale EIS,

the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The proposed CPA lease sale has the potential to impact a number of recreational fishing areas in the Gulf of Mexico. This section discusses the baseline environment for recreational fishing along the coasts of Louisiana, Mississippi, Alabama, and Florida; the baseline environment for recreational fishing along the coast of Texas is described in **Chapter 4.1.1.15.1**. Data on effort and catch levels for the most often fished species is discussed first. This is followed by a description of the interaction between recreational fishing activity and the broader economy of the region. Finally, an analysis of the effects of the DWH event on the recreational fishing industry is presented. While there is some evidence regarding the impacts of the oil spill on recent recreational fishing activity, a fair amount of uncertainty remains regarding the shape this industry will take as the impacts of the oil spill gradually recede.

Catch and Effort Data

Table 4-9 presents data on the most commonly landed species by recreational fishermen in Louisiana, Mississippi, Alabama, and Florida. These data, along with the majority of the other data presented, comes from the NMFS online database. **Table 4-9** presents the total number of fish caught and the total landings weight of certain fish species from 2001 through 2009 in these four states. In 2009, the most number of fish landings occurred for spotted seatrout, pinfish, red drum, sand seatrout, Atlantic croaker, and gray snapper. The species with the most total pounds landed in 2009 were spotted seatrout, red drum, sheepshead, red snapper, king mackerel, and black drum. The number of landings for most species has been somewhat stable over time. However, landings of species such as sand seatrout and Atlantic croaker have shown an uptrend in recent years, while landings of species such as striped mullet and cobia have exhibited a general downtrend. **Table 4-10** shows the percent of the catch in **Table 4-9** that occurred in ocean versus inland waters. As expected, these percentages are highly species dependent, ranging from almost 100 percent ocean-landed for dolphins and blackfin tuna to less than 10 percent for southern flounder and black drum. This information is particularly relevant in light of the DHW event, which appears to have had a more pronounced effect on ocean-based recreational fishing.

Table 4-11 presents data from two sources regarding angler participation in the Gulf of Mexico. Panel A presents data from NMFS and shows the total number of anglers in 2009 for each of the Gulf States in three categories: coastal; noncoastal; and out-of state. Coastal refers to anglers who are State residents of coastal counties, noncoastal refers to anglers who are State residents of noncoastal counties, and out-of-state refers to out-of-state residents. Florida has the largest number of recreational fishing participants. Florida's approximately 6 million anglers accounted for 78 percent of participants among the four Gulf States that participated in the surveys by NMFS. Louisiana has the second highest number of participants, followed by Alabama and Mississippi, respectively. Florida also has the highest percentage of out-of-state anglers, and Louisiana has the highest percentage of in-state anglers. Panel B presents participation data from the National Survey of Fishing, Hunting, and Wildlife Associated Recreation. The scales of the findings are reasonably similar, although the differences are certainly not negligible; other than different survey years, the causes of these discrepancies are not immediately clear. The National Survey of Fishing, Hunting, and Wildlife Associated Recreation occurred in 2006.

Table 4-12 presents data on the number of angler trips taken in each state in the Gulf of Mexico in 2009. Angler trips in West Florida accounted for approximately 70 percent of the 22 million trips in the Gulf of Mexico. There were approximately 4 million trips in Louisiana, 1.7 million trips in Alabama, and 1.1 million trips in Mississippi. **Table 4-13** also breaks down these trips by location and mode. The three geographic locations for each state are inland, State ocean waters (less than 3 mi [5 km] from shore), and Federal ocean waters (more than 3 mi [5 km] from shore). The three modes of fishing are shore fishing, charter fishing, and private/rental fishing. Approximately 67 percent of all recreational fishing trips in the Gulf of Mexico are conducted inland; fishing in State ocean waters accounts for approximately 27 percent of angler trips; and fishing in Federal ocean waters accounts for approximately 6 percent of the trips. Ocean fishing is more prevalent in Alabama and West Florida, which comprise approximately 40 percent of the total number of trips in each State. Offshore fishing only accounts for about 5 percent of trips in both Mississippi and Louisiana. The bulk of ocean fishing in the Gulf of Mexico is conducted through either shore fishing (37%) or private rentals (59%). Charter fishing accounts for less than 5 percent of the total number of angler trips.

Economic Effects of the Recreational Fishing Industry

Recreational fishing activity can affect a regional economy in a number of ways. The most direct manner in which anglers affect the economy is through direct spending on fishing-related goods and services. This direct spending includes both trip expenditures and expenditures on durable equipment. Trip expenditures include such things as transportation costs, boat fees, and bait expenses. Durable purchases include spending on things such as fishing equipment and fishing boats. **Table 4-14** presents data on total direct spending by anglers in each state along the Gulf of Mexico. There was approximately $12.5 billion in direct spending by anglers in 2008; roughly half of this spending occurred in West Florida. Louisiana and Texas each had over $2.5 billion in spending, while Alabama and Mississippi each had over $400 million in spending.

Direct spending by fishermen also supports firms in related industries along an economy's supply chain. In addition, spending by fishermen serves as income to other agents in an economy, which supports overall spending patterns. The NMFS conducted an economic analysis that attempted to quantify this dependence of the regional economy on recreational fishing activity (USDOC, NMFS, 2010d and 2010e); this analysis utilizes many of the techniques of an earlier study by Gentner and Steinbeck (2008). These studies utilize input-output economic models, which create multipliers that can be used to predict levels of sales, value added, and jobs that result from direct spending on recreational fishing. As can be seen in **Table 4-14**, direct spending by anglers supported approximately $12 billion in sales. One reason that sales are lower than spending is that only spending on newly produced goods contributes to economic activity (i.e., sales of used equipment does not). In addition, some spending that occurs by anglers would likely be replaced by spending by others if angler spending levels were to change. These sales contributed to $6 billion in value added in the economy. While the sales data aggregates spending at different stages of production, value added only includes the incremental production at each level in the supply chain. Finally, it is estimated that spending by anglers supports over 87,000 jobs in Louisiana, Mississippi, Alabama, and Florida.

Deepwater Horizon Event

Previous sections describe the baseline environment for recreational fishing in the Gulf of Mexico prior to the DWH event. The most direct impact of the spill on fisheries was to close a number of fishing grounds in or near the oil-impacted areas. At the peak of its impact in June 2010, the oil spill led to the closure of 36.6 percent of the fishing waters in the Gulf of Mexico; this percentage fell dramatically by mid-November to less than 1 percent. The NMFS continued to conduct angler surveys as the spill progressed. These data are presented in 2-month "waves" and thus provide a picture of the evolving state of recreational fishing in the Gulf of Mexico. **Table 4-12** presents data on the number of angler trips in each Gulf State for inland, State, and Federal waters in 2010; data for comparable months in 2009 are also presented. Prior to the DWH event, recreational fishing activity in the Gulf of Mexico was occurring at a pace that was slightly below the same time period the year before. After the spill, total angler activity did generally fall; however, this decrease in aggregate activity was not overly pronounced. This result is largely due to the fact that the majority of recreational fishing is conducted inland. Inland fishing did fall noticeably in May and June 2010 when compared with 2009, but by July and August 2010, inland fishing had recovered to a level of activity that was actually higher than in 2009. Angler trips in State ocean waters fell dramatically in Louisiana, while State ocean trips in Alabama and Florida were only modestly impacted. The effects of the spill were most pronounced Federal waters; for example, angler trips in Alabama fell from around 65,000 in July/August 2009 to only a few hundred in July/August 2010. Federal water angler trips also fell noticeably in Louisiana, although trips prior to the spill also seemed to be running at a below trend rate. **Table 4-15** presents data on the species of fish caught for the same time periods as were presented in **Table 4-12** in order to provide an initial sense of the impacts of the spill on individual species. Landings for most species in the Gulf of Mexico fell only modestly after the oil spill. Species landings that fell more significantly include gray snapper, red snapper, and red grouper.

While the previous data provide a useful picture of recreational activity as the spill progressed, there is more uncertainty regarding the long-term implications of the oil spill on recreational fishing. The most important determinant of the longer-term effects of the spill will be the manner in which the fish ecosystems in the Gulf of Mexico evolve in response to the spill. IEM (2010) provides an overview of the factors that determine the extent to which some fish species will be able to adapt to the spill.

However, one factor that makes these issues hard to gauge at this point is that, for many species, oil is more damaging to eggs and larvae than to adults. Thus, even if recreational fishing activity is maintained in the near term, it will take some time to observe if, and to what degree, the reproductive cycle of particular species has been impacted.

Impacts to the recreational fishing industry will also be determined by the ability of the people and firms in the industry to weather the current conditions. Fishing closures occurred during a normally strong period for recreational fishing. In addition, many firms that cater to recreational fishing are small and may lack the ability to weather the resulting lack of business. IEM (2010) presents some survey results regarding the effects of the spill on local fishermen. While a number of fishermen in affected areas were idled directly after the spill, Louisiana officials opened a number of areas to recreational fishing in mid-July 2010 (Federal Reserve Bank of Atlanta, 2010). In addition, a number of people were supported short term by BP claims and by the Vessels of Opportunity Program. For example, businesses and individuals in the fishing industry have received approximately $500 million in compensation payments as of November 2010 (Gulf Coast Claims Facility, 2010a).

The fate of the recreational fishing industry will also depend on the extent to which confidence can be restored in the tourism and seafood industries along the Gulf Coast. This is a particularly hard issue to quantify at this point, in part because this issue will be determined by the success of government policy initiatives. For example, Louisiana will receive $78 million from BP to monitor seafood and to promote tourism. Thus, while a number of fishermen and businesses catering to them have been financially damaged by the spill, it appears that, if long-term impacts to recreational fishing do result from the DWH event, they will primarily be determined by the extent to which the fish ecosystems in the Gulf of Mexico are able to adapt to the spill over time.

4.1.1.18.2. Impacts of Routine Events

Background/Introduction

A detailed description of the impacts of routine activities on recreational fishing can be found in Chapter 4.2.1.1.10 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.13 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational fishing incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Many of the species fished by recreational anglers are the same as those caught by commercial fishermen; one exception is menhaden, which is primarily a commercially fished species. The effects of routine OCS activities on commercial fishing are discussed in **Chapter 4.1.1.17.2**. Routine OCS actions can cause some minor disturbances to the fish populations that support recreational fishing activity. For example, OCS activity could cause coastal environmental degradation either through effects on water quality or on wetland habitat. The effects of OCS actions on essential fish habitat are discussed in more detail in **Chapter 4.1.1.16.2.** In addition, construction operations and vessel traffic could cause some degree of space-use conflict with recreational fishing vessels. However, these impacts are likely to be short lived and small in scale.

A unique manner in which OCS actions can increase recreational fishing activity is through the role of oil platforms as artificial reefs. Indeed, oil platforms often attract a large fish population due to their particular suitability as reef structures. The Atlantic and Gulf States Marine Fisheries Commissions provide a guidebook that compares the relative suitability of various materials for use as artificial reefs (Atlantic and Gulf States Marine Fisheries Commissions, 2004). Hiett and Milon (2002) estimate that over 20 percent of all recreational fishing activity in the Gulf of Mexico occurs within 300 ft (91 m) of an oil and gas structure. The role of oil rigs as artificial reefs becomes a particularly important issue during the decommissioning stage. Namely, the removal of an oil rig from a particular site has the potential to damage the fish assemblages that often develops on an oil rig, which would also affect recreational fishing activity in a particular area. However, the owner of an oil rig has the option to participate in the "rigs-to-reefs" program of the appropriate State. These programs allow for portions of oil platforms to remain in the water as reefs after the productive life of a platform has ended. Platforms that are a part of these programs are either toppled in place or moved to a location that is a suitable fish habitat. Rigs-to-reefs programs are discussed in more detail in Appendix D of the Multisale EIS. The U.S. policy towards

artificial reef creation is outlined in the *National Artificial Reef Plan: Guidelines for Siting, Construction, Development, and Assessment of Artificial Reefs* (USDOC, NOAA, 2007). This Agency's policy regarding rigs-to-reefs programs is outlined in *Rigs-to-Reefs Policy, Progress, and Perspective* (Dauterive, 2000) and was updated in *Rigs to Reefs Policy Addendum: Enhanced Reviewing and Approval Guidelines in Response to the Post-Hurricane Katrina Regulatory Environment* (USDOI, MMS, 2009d) in light of Hurricane Katrina.

Proposed Action Analysis

The CPA proposed action would lead to 32-44 oil and gas production structures. This could lead to minor space-use conflicts with recreational fishermen, primarily during the construction phase. The proposed action could also lead to some forms of environmental degradation that could affect fish populations, which would impact recreational fishing activity; these effects are discussed in more detail in **Chapter 4.1.1.16.2**. However, these effects are expected to be minimal, particularly given the small scale of the proposed action relative to the existing OCS oil and gas program.

The extent to which the proposed oil platforms would support recreational fishing activity would depend on their location. For example, oil rigs very far offshore are less likely to support recreational fishing activity. In addition, the extent to which a rig would serve as an attractor to fish would depend on the fish populations in nearby areas. Essential fish habitat maps of the Gulf of Mexico can be found on the Internet website of the Galveston Laboratory of NOAA Fisheries Service. Maps of artificial reef locations in Louisiana (Louisiana Dept. of Wildlife and Fisheries, 2010b), Mississippi (Mississippi Dept. of Marine Resources, 2010a), and Alabama (Alabama Dept. of Conservation and National Resources, 2010a) are also available.

Summary and Conclusion

There could be minor and short-term space-use conflicts with recreational fishermen during the initial phases of the CPA proposed action. The proposed action could also lead to low-level environmental degradation of fish habitat (**Chapter 4.1.1.16.2**), which would also negatively impact recreational fishing activity. However, these minor negative effects would likely be outweighed by the beneficial role that oil rigs serve as artificial reefs for fish populations. Each structure placed during the CPA proposed action has the potential to function as a *de facto* artificial reef. The degree to which oil platforms would become a part of a particular State's rigs-to-reefs program would be an important determinant of the degree to which the proposed action would impact recreational fishing activity in the long term.

4.1.1.18.3. Impacts of Accidental Events

Background/Introduction

A detailed description of the impacts of accidental events on recreational fishing can be found in Chapter 4.4.11 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.13 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational fishing incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The most direct manner in which oil spills and other accidental events would impact recreational fishing activity would be through their effects on fish habitats in the area impacted by the spill. A spill could either contaminate fish in the immediate area or cause fish to move during the duration of the spill. A spill would likely cause more direct harm to larvae and eggs than adults, which could affect recreational fishing in the longer term. The effects of accidental events on essential fish habitats are discussed in **Chapter 4.1.1.16.3**. The fish species most important to recreational fishing in certain regions are discussed in **Chapter 4.1.1.18.1**. A number of these species are similar to the species that are important to the commercial fishing industry; the effects of accidental effects on commercial fishing are described in **Chapter 4.1.1.17.3**. The majority of recreational fishing in the Gulf of Mexico occurs in the bays and wetlands areas along the Gulf Coast; the impacts of accidental events on wetland areas are described in **Chapter 4.1.1.4.3**.

The effects of an oil spill on recreational fishing are different from those experienced by the commercial fishing industry in several ways. Most directly, the benefits received by anglers from fishing activity are determined by subtle issues such as the enjoyment of the fishing process and the aesthetics of a particular fishing site. As a result, the damage of an oil spill to recreational fishing will be determined by issues such as the availability of substitute fishing sites in a region and the additional costs of attending alternate sites. These effects are most often analyzed using a variety of mathematical modeling techniques; an overview of these techniques is presented by the NRC (2006) and the European Inland Fisheries Advisory Commission (2010). Haab et al. (2000 and 2009) and Greene et al. (1997) are examples of applications of these methods to fisheries in the Gulf of Mexico. The *Exxon Valdez* spill was an example of a spill that occurred in an area with a large recreational fishing industry. Carson and Hanemann (1992) provide an economic analysis of the direct recreational fishing losses due to the spill; Mills (1992) provides a more descriptive analysis of the evolution of recreational fishing activity following the spill.

Any disruption to recreational fishing activity would also have broader economic implications to a particular geographic region. Disruptions to recreational fishing would affect boat launches, bait shops, and durable fishing equipment manufacturers. Gentner Consulting Group (2010) attempts to quantify the potential losses to State economies due to recreational fishing closures in light of the DWH event. This study uses the expenditure estimates and input output modeling framework of Gentner and Steinbeck (2008) to derive a daily measure of the potential losses in the economy due to fishing closures in the Gulf of Mexico. This study estimates that the recreational fishing industry contributes $9.8 million in direct expenditures, $23 million in total sales, and 183 jobs per day to the economy of the Gulf of Mexico. One can estimate the cost of a spill by restricting these estimates to a particular region and then multiplying the daily estimates by the total duration of a fishing closure brought about by an oil spill. It is also possible that an oil spill's effects on the recreational fishing industry could have broader effects on tourism. Namely, the loss of recreational fishing options at certain locations could dissuade visitors from taking trips to an overall area. Similarly, recreational fishing may suffer in areas not directly affected by oil due to uncertainty or to misperceptions regarding the extent of the oil damage. While these effects are difficult to quantify, the U.S. House of Representatives (2010) provides a descriptive overview of the tourism effects felt during the DWH event.

Proposed Action Analysis

The CPA proposed action would result in 149-263 producing oil wells, 144-237 producing gas wells, and 32-44 installed production platforms (**Table 3-2**). A spill at one of these sites would likely lead to recreational fishing closures in the immediate vicinity in the short term. Since oil rigs often are habitats for certain fish species, there could be noticeable impacts to the fish ecosystem in the area of the spill. In general, oil spills that are closer to shore would have greater impacts on recreational fishing activity. As can be seen in **Tables 4-9 and 4-15**, spotted seatrout, pinfish, red drum, sand seatrout, and Atlantic croaker, which are primarily caught in nearshore waters, are the most often caught fish species by anglers. A spill farther from shore would have more of an impact on species such as king mackerel and red snapper. Maps of fish habitats in the Gulf of Mexico that could be impacted by an oil spill can be found on the Internet website of the Galveston Laboratory of NOAA Fisheries Service and on NOAA's ERMA website (USDOC, NOAA, 2010f).

Summary and Conclusion

An oil spill would likely lead to recreational fishing closures in the vicinity of the oil spill. Small-scale spills should not affect recreational fishing to a large degree due to the likely availability of substitute fishing sites in neighboring regions. A rare large spill such as the one associated with the DWH event can have more noticeable effects because of the larger potential closure regions and because of the wider economic implications such closures can have. However, the longer-term implications of a large oil spill would primarily depend on the extent to which fish ecosystems recover after the spill has been cleaned. Because offshore spills have a small probability of contacting estuarine habitats that serve as nurseries for many recreational species and because inshore spills would have localized impacts to an area, oil spills would have a small effect on recreational fisheries.

4.1.1.18.4. Cumulative Impacts

Background/Introduction

A detailed description of the cumulative impacts to recreational fishing can be found in Chapter 4.5.12 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.13.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational fishing incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The cumulative impacts to recreational fishing activity from the CPA proposed action would arise from the existing 5-Year Program and from the expected progression of the recreational fishing industry in the Gulf of Mexico. These impacts are from the cumulative effects on fish resources in the Gulf of Mexico, which are discussed in **Chapter 4.1.1.16.4**. This chapter discusses the cumulative impacts of wetland loss, marine/estuary water quality degradation, damage to live bottoms, structure removals, petroleum spills, subsurface blowouts, pipeline trenching, and discharges of drilling mud and processed waters on fish resources. Because many of the recreationally sought fishes are also harvested commercially, a number of the cumulative impacts of the recreational fishing industry are similar to those of the commercial fishing industry. This is true even though recreational fishing is primarily confined to smaller, closer inshore areas of the Gulf of Mexico than commercial fishing. **Chapter 4.1.1.17.4** outlines the cumulative impacts of commercial fishing practices, hurricanes, installation of production and underwater obstructions, platform removals, seismic surveys, petroleum spills, subsurface blowouts, pipeline trenching, and the offshore discharge of drilling mud and produced waters on commercial fishing. The cumulative impacts unique to recreational fishing activity will arise from State and Federal fisheries management plans, the role of oil platforms as artificial reefs, and the lingering impacts of the DWH event.

State and Federal Fisheries Management Plans

The CPA proposed action could have cumulative impacts to the extent to which it alters or interacts with State and Federal Fisheries Management Plans. Recreational fishing activity is highly regulated, primarily to ensure a sustainable fisheries population through time. This often takes the form of catch limits per trip and quotas for overall catch per species during a given season. Recreational fishing activity in Federal waters is governed by the GMFMC; their most recent policies are outlined in *Recreational Fishing Regulations for Gulf of Mexico Federal Waters* (GMFMC, 2011). Each State has its own guidelines for recreational fishing in State waters. The following websites are where the State fisheries policies can be found: Louisiana Dept. of Wildlife and Fisheries (2010c); Mississippi Dept. of Marine Resources (2010b); Alabama Dept. of Conservation and Natural Resources (2010b); and Florida Fish and Wildlife Conservation Commission (2010c). Federal Fisheries Management Plans could exacerbate the impacts of OCS actions if both were to impact certain species or fishing sites. However, fisheries management plans could also serve to mitigate the effects of an oil spill since these plans are often designed to maintain stable fishing activity. For example, the GMFMC allowed for a supplemental red snapper season in October 2010 since red snapper catch was unusually low during the DWH event (GMFMC, 2010b). This supplemental red snapper season was designed to allow the 2010 quota for red snapper catch to be reached.

Rigs-to-Reefs and Artificial Reef Development

Oil and gas platforms constructed as a result of the CPA proposed action would contribute to the important role of existing OCS platforms and serve as artificial reefs for fish habitats. Platforms often attract a large fish population due to their particular suitability as reef structures. Hiett and Milon (2002) estimate that over 20 percent of all recreational fishing activity in the Gulf of Mexico occurs within 300 ft (91 m) of an oil and gas structure.

The role of oil rigs as artificial reefs becomes a particularly important issue during the decommissioning stage. Namely, the removal of an oil rig from a particular site has the potential to damage the fish assemblages that often develop at an oil rig, and this would also affect recreational

fishing activity in the area. However, the owner of an oil rig has the option to participate in the "rigs-to-reefs" program of the appropriate State. These programs allow for portions of oil platforms to remain in the water as reefs after the productive life of a platform has ended. Platforms that are a part of these programs are either toppled in place or moved to a location that is a suitable fish habitat. Rigs-to-reefs programs are discussed in more detail in Appendix A.4 of the Multisale EIS. The U.S. policy towards artificial reef creation is outlined in the *National Artificial Reef Plan: Guidelines for Siting, Construction, Development, and Assessment of Artificial Reefs* (USDOC, NOAA, 2007). This Agency's policy regarding rigs-to-reefs programs is outlined in *Rigs-to-Reefs Policy, Progress, and Perspective* (Dauterive, 2000) and was updated in *Rigs to Reefs Policy Addendum: Enhanced Reviewing and Approval Guidelines in Response to the Post-Hurricane Katrina Regulatory Environment* (USDOI, MMS, 2009d) in light of Hurricane Katrina. Maps of artificial reef locations in Louisiana (Louisiana Dept. of Wildlife and Fisheries, 2010b), Mississippi (Mississippi Dept. of Marine Resources, 2010a), and Alabama (Alabama Dept. of Conservation and National Resources, 2010a) are also available.

Deepwater Horizon *Event*

The DWH event may heighten the sensitivity of recreational fishing activity in the CPA to additional oil spills during the next several years. This is partly due to the fact that fish populations are still responding to the spill and the ultimate long-term outcomes are not yet clear. This is also due to the complex manner in which recreational fishing activity and tourism interact. Namely, recreational fishing activity is one of a number of factors that draw tourists to a particular region. The high level of national attention focused onto the DHW suggests that future oil spills, even if smaller in scale, could raise greater concerns regarding recreational fishing in affected areas among tourists. While this effect may be offset by additional fishing by others, any decrease in fishing-based tourism could have broader impacts to a local economy.

Summary and Conclusion

The CPA proposed action and the broader OCS Program have varied effects on recreational fishing activity. The OCS Program has generally enhanced recreational fishing opportunities due to the role of oil platforms as artificial reefs. This effect depends importantly on the extent to which rigs are removed at decommissioning or are maintained through "rigs-to-reefs" programs. However, oil spills can have important negative consequences on recreational fishing activity due to the resultant fishing closures and longer-term effects oil spills can have on fish populations. This was evident during the DWH event, the effects of which are not yet certain. However, this type of catastrophic spill event is rare. The contribution of the CPA proposed action to these positive and negative cumulative effects would be minimal because of the relatively small amount of activity expected with the proposed action. It is likely that Fisheries Management Plans of the Federal and State governments would serve to keep overall recreational fishing activity reasonably stable through time.

4.1.1.19. Recreational Resources

The BOEMRE has reexamined the analysis for recreational resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for recreational resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

The full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information is presented in the following sections. A brief summary of potential impacts follows. While marine debris and nearshore operations, either individually or collectively, may adversely affect the quality of some recreational experiences, they are unlikely to reduce the number of recreational visits to Gulf Coast beaches. It is unlikely that a spill would be a major threat to recreational beaches because any impacts would be short term and localized, and should have no long-term effect on tourism. The

incremental contribution of the CPA proposed action to cumulative impacts to recreational resources would be minor.

4.1.1.19.1. Description of the Affected Environment

A detailed description of recreational resources can be found in Chapter 3.3.3 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.14 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational resources incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The CPA proposed action has the potential to affect the diverse set of recreational resources located throughout the coast of the Gulf of Mexico. The Gulf Coast is one of the major recreational regions of the United States. The shorefronts along the coasts of Florida, Alabama, Mississippi, Louisiana, and Texas support activities such as beach visitation, marine fishing, and nature-based recreation. These recreational opportunities attract visitors from around the world to the region. As such, these recreational resources are integral components to the broader economy of the Gulf of Mexico, supporting activities such as restaurants, lodging, and transportation. The Gulf Coast recreation/tourism economy has generally performed well in past years; however, events such as hurricanes, the recent global economic downturn, and the DWH event and resulting oil spill have strained various components of the recreation and tourism industries; they have also affected the baseline conditions for these industries in some regions. This section discusses the baseline conditions for recreational resources along the coasts of Louisiana, Alabama, Mississippi, and Florida since these are the primary areas that could be impacted by the CPA proposed action. The economic significance of the recreation and tourism industries in the coastal zones of these states is presented first; this is followed by a more in-depth discussion of the structure of the recreational industries in Florida, Mississippi, Alabama, and Louisiana. This section then presents a discussion of the impacts of the DWH event on the Gulf Coast, since the most direct effects of the resulting spill were felt in these states.

Economic Significance of the Recreational Industry in the Gulf Coast

The recreation and tourism industries are major sources of employment along the Gulf Coast. **Table 4-16** presents employment statistics for a set of geographic regions in the Gulf of Mexico. Panel A presents data on the number of employees in the leisure/hospitality industry from 2001 through 2009 in 13 BOEMRE-defined economic impact areas (EIA's); these regions are defined in **Figure 2-2** (All employment data were obtained through the U.S. Dept. of Labor, Bureau of Labor Statistics). In **Table 4-16**, the leisure/hospitality industry corresponds to the definition used by the North American Industrial Classification System; this definition includes sub-industries such as entertainment providers, lodging services, and food/beverage services. Panel A shows that approximately 685,000 people worked in the leisure/hospitality industry in the Florida, Alabama, Mississippi, and Louisiana EIA's in 2009. FL-3 and FL-4 had the largest concentration of recreation employees, with a total of about 423,000 workers. LA-4 had a sizable recreation industry, having over 67,000 workers. Most of the EIA's showed steady employment growth from 2001 through 2008; employment fell in all EIA's except FL-1in 2009 with the onset of the global economic downturn during that time. A notable exception to the steady growth experienced by most regions occurred in 2005 in LA-4 and MS-1. Hurricane Katrina hit these two regions extremely hard, slashing tourism/recreation employment by almost half (the data presented is of December of that year; thus, the figure for 2005 should fully reflect the impact of Hurricane Katrina). Recreation employment in these regions has recovered a fair amount, although employment in 2009 is still below employment in 2004 in both LA-4 and MS-1 (U.S. Dept. of Labor, Bureau of Labor Statistics, 2010a).

Panel B of **Table 4-16** presents the number of employees in recreation/tourism in the EIA counties/parishes that are directly along the Gulf Coast. These counties/parishes are particularly vulnerable to the effects of an oil spill such as the DWH event. As can be seen in **Table 4-16**, there are over 566,000 recreation jobs in the Florida, Alabama, Mississippi, and Louisiana coastal EIA counties/parishes. Over 400,000 of these jobs are in Florida, whose economy is particularly dependent on coastal recreation. Panel C of **Table 4-16** presents data on the total number of jobs in the recreation and

tourism industries in each state; this data is primarily presented in order to provide some perspective on the relative size of the coastal recreational economies in these states. **Table 4-17** presents data on total wages earned in the leisure/hospitality industry for the same geographic regions discussed in **Table 4-16**. In 2009, workers in the leisure and hospitality industries in the Florida, Alabama, Mississippi, and Louisiana EIA's earned approximately $14 billion. The trends for each EIA over time are similar as was seen in **Table 4-16**. The effect on wages in 2005 in LA-4 and MS-1 from Hurricane Katrina would appear to less than that was observed for employment; however, this is simply a data issue since wages in 2005 include wages earned before the onset of Hurricanes Katrina and Rita in August and September 2005. It is worth noting that higher than average wages in LA-4, MS-1, and FL-4 lead total wages in these areas to represent a greater fraction of total wages than these areas have in total employment (the average salary of workers can be closely approximated by dividing total wages by total employment in any geographic region). Similarly, wages were lower than average in FL-2.

Table 4-18 presents data on total tourism spending in each of the Gulf States (U.S. Travel Association, 2010). This is a somewhat different perspective than the wage data of **Table 4-17**. Total spending is higher than total wages since only a fraction of tourism spending translates into wages. For example, a portion of spending will end up as profit to the owners of the enterprises. In addition, spending on some items, particularly manufactured goods, may translate into wages to workers that are not categorized as being in the leisure/hospitality industry. Thus, looking at total spending provides a broader measure of the impact of tourism on the economies of the Gulf States. However, it is important to note that the data in **Table 4-18** focuses only on spending by visitors and ignores spending on recreational activity by local residents. Therefore, the total economic impact of the recreation/tourism industry is somewhat greater than the data shows.

Table 4-18 shows that visitors to the Gulf Coast States of Florida, Alabama, Mississippi, and Louisiana spent approximately $94 million in 2008. The trends observed for spending are reasonably similar as was observed for wages. As seen in **Table 4-18**, there has been a gradual increase in tourism spending in most years in these states. We see the decline in spending in Louisiana and Mississippi associated with Hurricanes Katrina and Rita; however, 2006 was the first full year after the hurricanes and, thus, more fully reflects their impacts on tourism in these states.

A final perspective from which to view aggregate employment data is provided by Kaplan and Whitman (unpublished). This paper attempts to isolate those jobs that are particularly sensitive to OCS activities. For example, ocean and beach recreational activities are likely to be quite sensitive to OCS activities, particularly in the event of an oil spill. This is particularly true for some of the island-based recreational activities in the Gulf of Mexico; examples of these are Dauphin Island (Alabama) and the Gulf Islands National Seashore (Mississippi/Florida). However, a large portion of the jobs listed in **Table 4-16** occur in restaurants, gambling facilities, and a myriad of other types of recreational activities. While these types of activities can still be affected by OCS activities, these effects are less direct than for ocean-based tourism/recreation. Kaplan and Whitman (unpublished) attempt to account for this effect by weighting each recreational activity by the extent to which it applies to tourism activity, as well as the extent to which it is dependent on coastal resources.

Table 4-19 presents the estimated payroll, number of employees, and number of establishments associated with coastal travel, tourism, and recreation in 2004; there has not been a more recent study that uses an approach similar to Kaplan and Whitman. Kaplan and Whitman (unpublished) identify approximately 49,000 jobs in this category in Florida, Alabama, Mississippi, and Louisiana that support a payroll of approximately $583 million. Approximately half of these jobs occur in Florida. There is a fair amount of uncertainty in these numbers due to measurement issues and to events that have occurred since the measurement period, most notably hurricanes and the DWH event and resulting oil spill. However, Kaplan and Whitman still provide a rough sense of the scale of coastal recreational employment in each state from a unique perspective. Namely, these numbers represent a narrowly defined measure of jobs in the region; this is particularly true in light of the DWH event and resulting oil spill, the scale of which has the potential to affect a broader group of activities. However, it is still of use to identify the most at risk jobs in a particular area since the data can provide a rough sense of the scale of the broader effects OCS activities can have on activities that indirectly depend on these workers. Indeed, one of the particularly important contributions of this study is to estimate the number of coastal travel, recreation, and tourism jobs on a county-by-county basis, which can guide policymakers when analyzing the effects of the DWH event and oil spill and of future potential accidental events.

Another more positive way in which OCS activity can affect recreation is through the effect of oil and gas structures themselves. Namely, there is substantial recreational activity associated with these structures in the Gulf of Mexico from Alabama through Texas, and these activities have a considerable economic impact. An Agency study to determine the economic contribution of rig-associated recreational activities estimated that a total of 980,264 fishing trips were taken within 300 ft (91 m) of an oil or gas structure or an artificial reef created from such structures during 1999 out of a total 4.48 million marine recreational fishing trips in the Gulf, about 22 percent of the total (Hiett and Milon, 2002). While rigs as reefs contribute substantially to fishing, they are also the destination for the vast majority of recreational diving trips. The study found that there were 83,780 dive trips near oil and gas structures out of a total 89,464 dive trips taken, about 93.6 percent of the total. Overall, the study estimated a total of $172.9 million in trip related costs for fishing and diving near oil and gas structures, with $13.2 million in trip expenditures for diving and $159.7 million associated with trip expenses for recreational fishing.

Recreational Resources in Florida, Alabama, Mississippi, and Louisiana

Florida has the largest coastal recreation economy among the Gulf Coast States. Approximately 84 million visitors to Florida in 2008 spent approximately $70 billion statewide (Visit Florida Research, 2010; U.S. Travel Association, 2010). One of the primary recreational activities near the Gulf Coast of Florida is beach visitation, particularly in the northern Panhandle and in the southern half of the state. As can be seen in **Table 4-20**, USEPA reports 634 beaches in the 22 coastal counties along the Gulf of Mexico. The National Survey on Recreation and the Environment estimates that 22 million people from throughout the United States visit Florida beaches annually; the surveys that form the basis of this estimate were taken from 2005 through 2009. Alpert et al. (2008) estimate that there were 20 million out-of-state visitors and 2.2 million in-state visitors to Florida beaches in 2006. They estimate that beach tourism contributed $24.1 billion to Florida's economy in 2006 and supported approximately 275,000 jobs. Alpert et al. (2005) present a more detailed analysis of the economic impacts of beach tourism in Florida; they also provide information regarding the economic impacts of each beach region in Florida. For example, they estimate that beach visitors in the northwest and southwest beach regions in Florida spent $15.5 billion in 2002.

Florida is also the most economically significant state nationwide in a number of other coastal-related recreation activities. Florida has the largest recreational fishing industry in the Nation, with approximately 160 million fish landed in 2009 (USDOC, NMFS, 2010e). Additional information on recreational fishing can be found in **Chapter 4.1.1.18**. The recreational marine industry as a whole generated approximately $18.4 billion in spending and directly or indirectly supported 220,000 jobs in the region; this includes activities such as boating, marinas, fishing, and marine science research (Monterey Bay Aquarium Research Institute, 2008). Finally, the Florida system of State parks provided a direct economic impact of over $900 million (Monterey Bay Aquarium Research Institute, 2008); examples of these include the Gulf Islands National Seashore, St. George Island State Park, the DeSoto National Memorial, Big Cypress National Preserve, Apalachicola National Forest, and Everglades National Park. There are also national wildlife refuges along Florida's coast that are used for various recreational activities; examples of these include Aucilla Wildlife Management Area, Cecil M. Webb State Wildlife Management Area, and Steinhatchee Conservation Area. Estimates of the economic significance of some of these facilities can be found in Kaplan and Whitman (unpublished); the geographic location of these parks, as well as information on the extent to which they were affected by the DWH event, can be found using NOAA's ERMA mapping system (USDOC, NOAA, 2010f).

Tourism and recreation accounted for $7.7 billion in tourism spending and 160,000 jobs in Alabama. Approximately 35 percent of spending and 36 percent of recreational employment in Alabama occurs along the Gulf Coast (Alabama Tourism Department, 2009). Mobile County has around 15,000 recreation workers, while Baldwin County has an additional 9,000 workers (U.S. Dept. of Labor). Approximately 21 million people visited the State of Alabama as a whole (Alabama Tourism Department, 2009). The coastal areas are particularly dependent on beach recreation and wildlife activities (such as birding). For example, approximately 1 million people participated in wildlife viewing in Alabama in 2006 (USDOI, 2006). Much of this activity occurs in State parks and refuges; examples of these include Maeher State Park, Gulf State Park, and the Marine Resources Division Laboratory on Dauphin Island.

Visitors to Mississippi spent approximately $6.3 billion in 2008, which helped to support 125,000 leisure/hospitality jobs statewide. Approximately $1.8 billion of this spending and 27,000 of these jobs occur in the Gulf Coast region (U.S. Dept. of Labor, Bureau of Labor Statistics, 2010a; Mississippi Development Authority, 2010). Harrison County has the highest tourism employment in the region, with approximately 19,000 jobs. One of the primary contributors to the Gulf Coast recreation industry in Mississippi is the casino gaming industry that accounts for approximately 35 percent of recreational employment in the State (Mississippi Development Authority, 2010). Mississippi had 30 State-licensed casinos as of June 30, 2009; these casinos had revenues of $2.6 billion in 2009. Nine of these casinos are located along the Gulf of Mexico and had revenues of approximately $1.2 billion in 2009. In addition, the Mississippi District of the Gulf Islands National Seashore is an important recreational area; more information on the Gulf Islands National Seashore can be found through the National Parks Service (USDOI, NPS, 2010).

The leisure hospitality industry in Louisiana brought in $9.6 million in spending and supported 190,000 jobs Statewide in 2008. The EIA parishes with over 10,000 recreation workers are Calcasieu, Lafayette, East Baton Rouge, Jefferson, and Orleans (U.S. Dept. of Labor, Bureau of Labor Statistics, 2010a). Jefferson and Orleans Parishes are the largest coastal recreation centers, with much of the tourism activity being driven by the various attractions of the New Orleans area. The recreation activity in these two parishes has been in a state of flux in recent years as they have attempted to recover from Hurricanes Katrina and Rita. For example, recreation employment in Orleans Parish fell from 43,508 in December 2004 to 18,064 in December 2005; it recovered to a level of 31,449 in December 2009 (U.S. Dept. of Labor, Bureau of Labor Statistics, 2010a). The recreational activity in the remaining coastal counties in Louisiana centers around Cajun culture, wetlands, and wildlife activities. State parks in the coastal zone of Louisiana include Cypremort Point State Park, Palmetto Island State Park, Grand Isle State Park, St. Bernard State Park, and Fontainebleau State Park; a map of these parks can be found at (Louisiana Dept. of Culture, Recreation, and Tourism, 2010). Coastal Louisiana is also characterized by a vast array of wildlife refuges that support a variety of recreational activities; those that are closest to the Gulf of Mexico include Sabine National Wildlife Refuge, Rockefeller State Wildlife Refuge and Game Preserve, Russell Sage Foundation Marsh Island State Wildlife Refuge, Atchafalaya Delta State Wildlife Management Area, Pointe Aux Chenes Wildlife Management Area, Delta National Wildlife Refuge, Pass a Loutre State Wildlife Management Area, Biloxi State Wildlife Management Area, Breton National Wildlife Refuge, and Bayou Savage National Wildlife Refuge. Estimates of the economic significance of some of these areas can be found in Kaplan and Whitman (unpublished); the geographic location of these areas, as well as information on the extent to which they were affected by the DWH event, can be found using NOAA's ERMA mapping system (USDOC, NOAA, 2010f).

Change in Baseline Conditions due to the *Deepwater Horizon* Event

The previous discussion presents the tourism/recreation baseline prior to the DWH event and resulting oil spill. This oil spill was a major event that affected the recreation industry in a number of ways. The most direct effects of the spill were on recreational fishing and on beach visitation. For example, at the height of its impact, the spill had closed 36.6 percent of recreational fishing areas in the Gulf of Mexico (this occurred on June 2); as of November 15, 2010, this percentage had dropped to less than 1 percent (USDOC, NOAA, 2010j); see **Chapter 4.1.1.18** for more information on the short-term impacts of the oil spill on recreational fishing activity. In addition, several beaches between eastern Louisiana and the northeast corner of Florida have experienced either advisories or closures to the spill (a list of these advisories/closures can be found at National Resources Defense Council, 2010). The NOAA's ERMA system also provides an updated graphical account of the extent to which certain coastal regions were impacted by the spill; for example, in November 2010, the primary areas that remained somewhat oiled were in Barataria Bay, Grand Isle, Breton National Wildlife Refuge, and some of the smaller islands off the coast of Gulfport, Mississippi (USDOI, NOAA, 2010f).

The effects of the spill, however, were broader than the effects to the contaminated fishing sites and beaches. For example, Butler and Sayre (2010) found that restaurants, hotels, and boating activities were noticeably impacted in coastal Mississippi as a result of the oil spill. It also appears that the effects on these industries reached beyond the areas in which oil actually came ashore; examples of these findings include The Knowland Group (2010) and the Federal Reserve Bank of Atlanta (2010). This effect could

be due to both misperceptions about the extent of the spill, as well as general hesitation to visit a general region impacted by an event such as the DWH event. For example, the Mississippi Development Authority (2010) conducted a study of perceptions of the extent to which Louisiana was impacted as the spill progressed. It also appears that the influx of relief workers, as well as the compensation payments received by affected workers, altered the complexion of those who were economically helped and hurt by the spill. For example, one analysis found a noticeable increase in hotel receipts in coastal Louisiana and on the Mississippi/Alabama border during the summer of 2010 compared with the summer of 2009; this same study found that counties in the northwest corner of Florida experienced a noticeable decrease in receipts during the same time periods (Gulf of Mexico Oil Spill Blog, 2010).

For the purposes of analyzing the baseline environment, there is an important distinction between those effects that occurred during the spill versus those that will persist now that the spill has been stopped. The most direct manner in which the effects of the oil spill will persist will be as a result of resources that will remain damaged for some time. It appears that reasonably rapid progress has been made regarding the removal of oil from beaches and other coastal areas in the Gulf of Mexico. For example, the length of oiled coastline has decreased from 658 mi 1,059 km) on August 6, 2010, to approximately 95 mi (153 km) on October 27, 2010 (RestoreTheGulf.gov, 2010d and 2010e). However, more uncertainty remains regarding the effects of the oil spill on the fish ecosystems in the Gulf of Mexico. Even if the fish ecosystems emerge in a reasonable period of time, it will likely take some time for recreational fishing activity in the region to return; it will also take time to restore confidence in the seafood industry in the region. Similarly, tourists will likely only gradually return to the beach areas in the vicinity of the oil spill.

Oxford Economics (2010) conducted a study of recent catastrophic events in order to estimate the longer-term economic implications of the DWH event and resulting oil spill. For example, they examine the extent to which the *Exxon Valdez* spill and the *Ixtoc* oil spill of 1979 are comparable to the DWH; more information on the *Ixtoc* spill can be found in (USDOI, BLM, 1982). They estimate that the long-term economic damage from the spill could be between $7.6 and $22.7 billion. Analyzing previous oil spills and other catastrophic events, they also suggest that it could take 15-36 months for the tourism industry to recover to pre-spill levels. Given Florida's dependence on fishing and beach activities (as well as the overall size of its economy), this study suggests that the State will bear the majority of the economic damage from the spill. However, it is important to recognize the uncertainty inherent in attempting to predict the speed at which the tourism industry will recover. A number of factors will come in to play; for example, the extent to which the broader economy rebounds from the serious recent recession will likely come in to play. In addition, the policy actions of State and local governments will influence the extent to which confidence in the region can be restored. The BOEMRE will continue to monitor developments in the region and will update the baseline estimates of recreation and tourism in the Gulf of Mexico as new information becomes available.

4.1.1.19.2. Impacts of Routine Events

Background/Introduction

Routine OCS oil and gas activities can affect recreation and tourism in diverse ways. The OCS activities can have direct negative impacts on beach and coastal recreational resources through discharges of marine debris, noise, and visual impairments. There are also possible indirect impacts on local recreational resources from space-use conflicts and from increased economic activity from OCS operations. The unique role that oil platforms can play as artificial reefs should also be accounted for when considering policy actions. Finally, the possible effects of public perceptions on tourism, particularly in light of the DWH event, should be considered. In summary, while impacts on recreational resources from routine OCS activities can occur from a number of sources, in total they are likely to be reasonably small in scale.

Beach- and coastal-related recreational resources are the most vulnerable to routine OCS operations. The potential for OCS-related marine debris to wash up along beaches is one of the most immediate concerns. Marine debris originates from OCS operations, sewage treatment plants, recreational and commercial fishing, industrial manufacturing, and various forms of vessel traffic. The prevalence of marine debris is an important global problem and can noticeably detract from the aesthetic value of recreational beaches. Various government agencies participate in a coordinated effort to combat marine

debris; a broad summary of the issues involved and the policy structure with respect to marine debris can be found in the report of the Interagency Report on Marine Debris Sources, Impacts, Strategies, and Recommendation (USDOC, NOAA, 2008b). There is also a national monitoring program in place to track the progression of the marine debris problem in various locations (Sheavly, 2007). McIlgorm et al. (2009) presents an economic analysis of the costs of marine debris and of programs designed to minimize debris. Besides these general responses, there are a number of regulations in place to minimize the potential for marine debris to be released due to OCS activities. This Agency issued an NTL that explains the actions oil and gas operators are required to implement (USDOI, MMS, 2002a). It is likely that this regulatory framework will keep the discharge of marine debris from OCS facilities to a reasonably low level.

There are also potential negative impacts on beach tourism from vessel noise and from the visibility of OCS infrastructure. While the potential effects of noise on tourism are difficult to quantify, several characteristics of the OCS industry serve to mitigate the potential for noise effects. First, most OCS-related vessel traffic moves between onshore support bases and work and production areas far offshore. Support bases are located in industrial ports, which are usually distant from recreational use areas. Second, OCS vessel use of approved travel lanes should help to separate this traffic from recreational resources and to keep noise fairly transitory and thus unlikely to noticeably impact tourism. The extent to which the visibility of OCS platforms can affect tourism depends primarily on the distance of platforms from shore and on the size of the particular oil rig. For example, a study by the Mississippi Development Authority found that a 50-ft (15-m) high production platform was identifiable 3 mi (5 km) from shore and a 100-ft (30-m) high production platform was visible 10 mi (16 km) from shore (Collins Center for Public Policy, 2010). All OCS platforms are at least 3 mi (5 km) from shore and most are beyond 10 mi (16 km) from shore. However, should a platform be visible, the scale of its impact on tourism would likely be small unless it interrupted the vision of other important landscape features.

Oil platforms constructed along with OCS activities serve unique roles as artificial reefs. Soon after deployment, an oil platform attracts a wide variety of fish species and other organisms to its structure. As a result, some offshore platforms are important components to the recreational fishing industry; oil platforms are also hosts to a large amount of recreational diving activity (Hiett and Milon, 2002). The role of oil rigs as artificial reefs also raises a number of issues during the decommissioning stage of an oil platform's life. Each Gulf Coast State has a mechanism for allowing some oil platforms to remain in place and to continue to serve as artificial reefs after oil production has ceased; Dauterive (2000) provides an overview of these programs. McGinnis et al. (2001) also discusses the broader economic implications of decommissioning oil structures. This decommissioning stage has the potential to affect recreational resources in a particular area if a rig is ultimately not maintained for reef purposes or if the rig is moved to a different location.

The OCS oil and gas activity can also affect recreational resources indirectly due to a number of economic factors. First, increased onshore infrastructure necessary to support offshore activities can create space-use conflicts. For example, Brody et al. (2006) present an analysis of space-use conflicts for oil and gas activities off the coast of Texas, although the issues they raise would be generally applicable to OCS activities in the other Gulf Coast States as well. They used a GIS-based framework to identify specific locations where conflicts between oil activities and other concerns (including recreational use) are most acute; they found that recreational use conflicts tend to be concentrated around some of the major wildlife viewing and beach areas near the larger population areas in Texas. In addition, the effects of OCS activities on the structure of employment in local economies have the potential to increase or decrease the demand for recreational resources in these communities. Increased demand for recreational resources has the potential to attract new recreational firms to a community; however, increased demand also has the potential to lessen the enjoyment of a particular resource by some community members. Mason (2010) provides some context on the interdependence of the offshore oil and gas industry with other sectors of the economy of the Gulf of Mexico; for example, they show that accommodation and food service resources have a reasonably high dependence on OCS activities. Wallace et al. (2001) also discuss community level effects of OCS activities on some of the local economies in the Gulf of Mexico; for example, this study presents descriptive evidence regarding concerns some local residents have regarding the impacts of OCS activities on recreational opportunities. However, given the limited scale of the proposed action relative to the existing oil and gas industry, the scale of the indirect economic impacts caused by new leasing activity is likely to be small.

While the DWH event primarily affects the baseline environment and our understanding of the impacts of accidental events, it also raises issues regarding the effects of OCS routine actions on recreation and tourism. Because of the particular sensitivity of tourism activity to public perceptions, concerns over offshore oil operations could potentially cause routine OCS actions to have impacts even in the absence of a future spill. This is primarily the case for recreational resources that require investment in real estate or other long-term fixed assets. For example, the DWH event has apparently caused a noticeable fall in property values in some areas in the Gulf of Mexico (see CoreLogic [2010] for preliminary data on some of these effects). Effects on property values may prove transitory. However, this impact could negatively impact recreational resources should this decline be long lived and lead to a reduction in the construction of recreational resources or to a decline in the use of existing recreational facilities. While the scale of this effect is unclear, it is likely that the incremental effect of the CPA proposed action would be small given their size relative to ongoing OCS oil and gas operations.

Proposed Action Analysis

The CPA proposed action would result in 149-263 producing oil wells, 144-237 producing gas wells, and 32-44 installed production platforms. Marine debris would be lost from time to time from OCS operations associated with drilling activities projected to result from the CPA proposed action. Current industry waste management practices, training and awareness programs focused on the beach litter problem, and the OCS industry's continuing efforts to minimize, track, and control offshore wastes are expected to minimize the potential for accidental loss of solid wastes from OCS oil and gas operations.

The CPA proposed action is expected to result in 3,425-5,500 service-vessel trips and 25,100-56,025 helicopter operations annually. Service vessels are assumed to use established nearshore traffic lanes, and helicopters are assumed to comply with areal clearance restrictions at least 90 percent of the time. These actions tend to distance traffic from recreational beach users and thus minimize its effects. The additional helicopter and vessel traffic would add a low level of noise pollution that would affect beach users.

The CPA proposed action would have a number of broader economic impacts, some of which have the potential to affect recreational resources in the Gulf of Mexico. This issue is of particular interest in the CPA due to the higher relative scale of the CPA proposed action compared with the WPA proposed action. The employment and income effects are likely to be felt in the Houston, Texas, area and in coastal Louisiana. Loren C. Scott & Associates (2008) presents an analysis of the particular economic importance of Port Fourchon and its impacts on the local region of Houma. Houston is at the center of a large inland metropolitan area connected to the Gulf by an industrial canal. The potential economic effects of the CPA proposed lease sale on recreational resources would not be identifiable in the Houston area, given the size and location of this metropolis. Recreational resources in coastal Louisiana could be affected by space-use conflicts and by increased use of recreational resources in local areas; however, these effects are likely to be small in scale due to the already entrenched nature of the oil industry in these areas. The role of perceptions on recreational activity in light of the DWH event has the potential to be an issue for most areas along the Gulf Coast. This is notably true for recreation in Florida, which, although not bordering the CPA, could be impacted by public perceptions raised by lease sites close enough to the Florida shore. The Collins Center for Public Policy (2010) presents a discussion of the potential impacts of oil and gas operations to Florida. Hagerty and Ramseur (2010) present a broader perspective of the economic impacts of the oil spill on tourism; this study also points out that the tourism promotion programs that have been enacted in the Gulf Coast States has the potential to mitigate some of the negative impacts from OCS operations on tourism.

Summary and Conclusion

Routine OCS actions in the CPA could cause minor disturbances to recreational resources, particularly beaches, through increased levels of noise, debris, and rig visibility. Because offshore spills have a small probability of contacting estuarine habitats that serve as nurseries for many recreational species and because inshore spills would have localized impacts to an area, oil spills would have a small effect on recreational fisheries. Routine activities could also cause minor changes the composition of local economies through changes in employment, land-use, and recreation demand. The CPA proposed action has the potential to directly and indirectly impact recreational resources along the coastal areas

adjacent to the CPA. However, the small scale of OCS activities relative to the scale of the existing oil and gas industry is such that these potential impacts on recreational resources are likely to be minimal.

Spills most likely to result from the CPA proposed action would be small, of short duration, and not likely to impact Gulf Coast recreational resources. Should an oil spill occur and contact a beach area or other recreational resource, it would cause some disruption during the impact and cleanup phases of the spill. However, these effects are also likely to be small in scale and of short duration. This is because the size of a coastal spill is projected to be small (coastal spills are assumed to be 5 bbl; Table 4-13 of the Multisale EIS), and the probability of an offshore spill contacting most beaches is small. In the unlikely event that a spill that is sufficiently large to affect large areas of the coast occurs and, through public perception, has effects that reach beyond the damaged area, effects to recreation and tourism could be significant. The DWH event was such a case; the resulting spill damaged some coastal resources but had economic effects in a much larger area. The role of perception on tourism activity was a particularly important feature of the DWH event, one that should become better understood as the aftermath of the spill unfolds.

4.1.1.19.3. Impacts of Accidental Events

Background/Introduction

A detailed description of the effects of accidental events on recreational resources can be found in Chapter 3.3.3 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.14 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational resources incorporated from: the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

This chapter first presents background information that is relevant to either a CPA or WPA proposed action. This includes an analysis of the effects of previous oil spills, as well as new information that has become available in light of the DWH event. This section then presents a discussion of some issues that are unique to the CPA proposed action.

The recreational resources most vulnerable to an oil spill are beaches and nature parks along the Gulf Coast. The ESI's provide overall measures of the sensitivity of a particular coastline to a potential oil spill (USDOC, NOAA, 2010k). The ESI's rank coastlines from 1 (lease sensitive) to 10 (most sensitive); ESI maps also provide point indicators for recreational resources. Marshes and swamps are examples of resources that have ESI's of 10 due to the extreme difficulty of removing oil from these areas. The ESI's for beach areas generally range from 3 to 6, depending on the type of sand and the extent to which gravel is mixed into the beach area. The ESI maps for any coastline along the Gulf of Mexico can be viewed using NOAA's ERMA mapping system (USDOC, NOAA, 2010f).

The effects of an oil spill on a particular beach region will depend on the success of the containment and cleanup operations following an oil spill. The NOAA provides a broad overview of the procedures used to assess oiled beaches (USDOC, NOAA, 2000). Both manual and machine-based techniques can be used to clean oil; the cleaning technique chosen for a particular beach will depend on the nature of the oiling of a particular beach area. Oil that remains on beach surfaces is often easier to clean than oil that seeps deeper into the ground. Overall, there appeared to be reasonably rapid progress in cleaning the coastline following the DWH event; for example, the length of oiled coastline has decreased from 658 mi (1,059 km) on August 6, 2010, to approximately 95 mi (153 km) on October 27, 2010 (RestoreTheGulf.gov, 2010d and 2010e). However, Wang and Roberts (2010) argue that a fair amount of the oil from the DWH event may be buried below the beach surfaces in some areas, which can cause problems to the long-term recreational and ecological uses of these areas.

Recreational resources such as beaches serve as important bases for certain local economies. Therefore, oiled beach regions can cause economic losses to both individuals and firms in the area of an oiled or closed beach. Parsons and Kang (2007) perform an economic analysis of the costs of hypothetical beach closures along the Texas Gulf Coast. They estimate that the economic costs of beach closures along the Padre Island National Seashore would range from $26,000 to $172,000, depending on the time of year the closures would occur. The oil spill off the Tampa Bay, Florida, coast in 1993 is an example of a spill that affected recreational beaches. Damage to these beaches and other recreational resources was determined to cause $2.5 million in damages to the affected parties in the area (Florida

Dept. of Environmental Protection and USDOC, NOAA, 2000). Finally, the New Orleans oil spill of 2008 demonstrates that a spill can affect different types of recreational activities. Namely, this spill impacted some of the boating and restaurant businesses in the vicinity of the spill; it also caused some aesthetic impacts to the experiences of tourists in the region (Tuler et al., 2010).

The DWH event was much more significant in size and duration than the previously mentioned spills. As such, it raises important questions regarding the impacts of oil spills on recreation and tourism. One important point is that a spill of the DHW event's dimensions can influence a much broader range of individuals and firms than can a smaller spill. For example, a small, localized spill may lead some travelers to seek substitute recreational opportunities in nearby areas. However, a large spill is more likely to dissuade travelers from visiting a broader economic region. Similarly, mid-sized restaurant chains and hotels may be able to find other customers or to simply weather a smaller spill. However, a spill the size of the DWH event is more likely to affect these types of firms since they are less able to diversify their customer base. These effects can be seen in the makeup of those who have filed damage claims with BP (Gulf Coast Claims Facility, 2010a). For example, the bulk of the claims by individuals have been made in the food, beverage, lodging sector and in the retail, sales, and service sector. Claims have also been made by individuals and firms in a broad range of geographic regions, many of which were not directly impacted by oil. The claims process and the cleanup process must also be taken into account when attempting to ascertain the ultimate impacts of a spill on a recreational economy. For example, one analysis found a noticeable increase in hotel receipts in coastal Louisiana and on the Mississippi/Alabama border during the summer of 2010 compared with the summer of 2009; this same study found that counties in the northwest corner of Florida experienced a noticeable decrease in receipts during the same time periods (Gulf of Mexico Oil Spill Blog, 2010). While the spill caused economic damage to a number of people in the Louisiana and Mississippi/Alabama border area, this example demonstrates that the effects of cleanup and damage mitigation activities must be taken into account when analyzing the overall impact of a spill on recreational economies.

The broad impact of the DWH event also highlights the critical role of media coverage and public perceptions in determining the extent to which an oil spill will affect the recreational economy. Namely, there were a number of reports that various effects on tourism were felt in areas beyond the locations in which oil washed up along beaches and other areas. A Congressional hearing into this matter (U.S. House of Representatives, 2010) provides a broad overview of some of the effects that were felt along the Gulf Coast. For example, a representative of Pinellas County estimated that this area had lost roughly $70 million in hotel revenue even though beaches in this area did not receive any oil damage. This type of effect could be due to misperceptions about the spill, uncertainty about the future of the spill, or concerns about whether a tourism experience will be affected even if the destination is only within close proximity to a spill. While these effects are complex and largely determined by the dynamics of a particular spill, the DWH event demonstrates that they must be considered as part of the full effects of a spill.

Oxford Economics (2010) attempts to quantify these effects by analyzing the impacts of recent catastrophic events on recreational economies. For example, they analyzed the *Ixtoc* oil spill of 1979, the scale and nature of which is reasonably similar to the DWH event. In this example, it took approximately 3 years for beaches to be cleaned and for recreational activity to return to similar levels as before the spill. More information regarding the economic effects of the *Ixtoc* spill can be found in (USDOI, BLM, 1982). They also looked at the *Prestige* oil spill of 2002 off the coast of Spain. Given the nature and size of that spill, recreational activity was able to return to pre-spill levels in approximately 1 year. More information regarding the *Prestige* spill can be found in Garza et al. (2009). Oxford Economics (2010) estimates that the long-term economic damage from the DWH event's resulting spill to be between $7.6 and $22.7 billion. Given Florida's dependence on fishing and beach activities (as well as the overall size of its economy), this study suggests that the State might bear the majority of the economic damage from the spill even though it experienced fewer physical impacts than did other states. However, this conclusion is highly uncertain since it depends so greatly on the role of perceptions on recreational activity. It is likely our understanding of the role of oil spills on perceptions and tourism will improve as the aftermath of the DWH event unfolds.

Proposed Action Analysis

Spills of the magnitude of the DWH event are high impact but low-probability events. Catastrophic spills are discussed in **Appendix B**. The risk of a spill occurring from the CPA proposed action and contacting recreational beaches is described in Chapter 4.3.1.8 of the Multisale EIS. Figure 4-13 of the Multisale EIS displays the probabilities of oil spills ≥1,000 bbl occurring and contacting certain shorelines as a result of the CPA proposed action. The probabilities of an oil spill occurring and contacting the shoreline are greater than 0.5 percent in the following parishes and counties: Cameron, Vermillion, Iberia, Terrebonne, Lafourche, Jefferson, St. Bernard, and Plaquemines Parishes in Louisiana; and Jefferson and Galveston Counties in Texas. Figure 4-13 of the Multisale EIS provides the probabilities of oil spills ≥1,000 bbl occurring and contacting recreational beach areas or State offshore waters within 10 days as a result of the CPA proposed action. As can be seen, the CPA proposed action has a 5-9 percent chance of impacting Louisiana's beach regions, while the probability of reaching Texas's beach regions is less than 1 percent.

The ESI maps of the coastline of the Gulf of Mexico can be found using NOAA's ERMA mapping system (USDOC, NOAA, 2010f). Most pieces of the beach region in western Louisiana have an ESI rating of 3, suggesting that a small-scale spill would be able to be cleaned in a reasonable period of time. However, the vast majority of the nature preserves along the remainder of coastal Louisiana are characterized by marsh and swamp areas, which have an ESI of 10. Oil entering these recreational areas would take a fair amount of time and effort to clean. This would have a particular impact on recreational fishing activity; more information regarding recreational fishing can be found in **Chapter 4.1.1.18**. However, given that recreational uses of these areas are less densely concentrated, it would take a large-sized spill to alter the structure of the recreational industry in a particular region.

Summary and Conclusion

Spills most likely to result from the CPA proposed action would be small, of short duration, and not likely to impact Gulf Coast recreational resources. Should an oil spill occur and contact a beach area or other recreational resource, it would cause some disruption during the impact and cleanup phases of the spill. However, these effects are also likely to be small in scale and of short duration. In the unlikely event that a spill occurs that is sufficiently large to affect large areas of the coast and, through public perception, have effects that reach beyond the damaged area, effects to recreation and tourism could be significant. The DWH event was such a case; the resulting spill damaged some coastal resources but had economic effects in a much larger area. The role of perceptions on tourism activity was a particularly important feature of the DWH event, one that should become better understood as the aftermath of the spill unfolds.

4.1.1.19.4. Cumulative Impacts

Background/Introduction

A detailed description of the cumulative effects on recreational resources can be found in Chapter 3.3.3 of the Multisale EIS. Additional information for the 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.14 of the 2009-2012 Supplemental EIS. The following information is a summary of the description of recreational resources incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The cumulative impacts to recreational resources would occur through the proposed action, the existing OCS Program, and from the expected impacts of external events and actions to recreational resources and tourism activity. The proposed action would contribute to a number of aesthetic and space-use issues arising from existing oil and gas programs. Oil spills can also impact the recreational uses of beaches and wetland areas, which are already being impacted through coastal erosion. Finally, lingering impacts of the global recession and the DWH event's oil spill would contribute to the incremental impacts of an oil spill, should one arise from the proposed action.

Aesthetic Impacts

The CPA proposed action would contribute to some negative aesthetic impacts of the existing OCS Program and of State oil and gas programs. First, oil and gas activities would contribute to the marine debris problems experienced by the Gulf Coast. Marine debris originates from OCS operations, sewage treatment plants, recreational and commercial fishing, industrial manufacturing, and various forms of vessel traffic. The prevalence of marine debris is an important global problem and can noticeably detract from the aesthetic value of recreational beaches. Various government agencies participate in a coordinated effort to combat marine debris; a broad summary of the issues involved and the policy structure with respect to marine debris can be found in the report of the Report on Marine Debris Sources, Impacts, Strategies, and Recommendation (USDOC, NOAA, 2008b). There is also a national monitoring program in place to track the progression of the marine debris problem in various locations (Sheavly, 2007). McIlgorm et al. (2009) presents an economic analysis of the costs of marine debris and of programs designed to minimize debris. Besides these general responses, there are a number of regulations in place to minimize the potential for marine debris to be released due to OCS activities. This Agency issued an NTL that describes and explains the actions oil and gas operators are required to implement (USDOI, MMS, 2002a). It is likely that this regulatory framework would keep the discharge of marine debris from OCS facilities and its contributions to the cumulative impacts of marine debris to a reasonably low level.

The oil platforms and infrastructure that arise from the CPA proposed action would contribute to the existing visibility of oil facilities along the Gulf Coast. The extent to which the visibility of OCS platforms can affect tourism depends primarily on the distance of platforms from shore and on the size of the particular oil rig. For example, a study by the Mississippi Development Authority found that a 50-ft (15-m) high production platform was identifiable 3 mi (5 km) from shore and a 100-ft (30-m) high production platform was visible 10 mi (16 km) from shore (Collins Center for Public Policy, 2010). All Federal OCS platforms in the CPA are at least 3 mi (5 km) from shore and most are 10 or more miles (16 or more kilometers) from shore. In addition, the visibility of OCS infrastructure is unlikely to noticeably detract from recreational uses unless it blocks the sight path of significant landmarks. Finally, the CPA proposed action would contribute incrementally to helicopter and vessel noise due to routine OCS operations. This would likely be most acute during the construction phases near service-vessel ports. However, the use of approved traffic lanes and times should keep the disturbance of these activities to recreational users to a minimum.

Space-Use Conflicts

The CPA proposed action would incrementally contribute to space-use conflicts that exist between OCS operations and some recreational uses. Conflicts could primarily arise with recreational boaters and fishermen; the nature of the space use of OCS operations is discussed in Chapter 4.1.1.3.3.2 of the Multisale EIS. Space-use conflicts from the CPA proposed sale could occur in the WPA as well. Much of the recreational activity that could conflict with OCS operations occurs near parks and wildlife refuges; the locations of these sites and other recreational use sites can be found using NOAA's ERMA mapping system. The OCS service-vessel ports are presented in **Figure 3-5**; onshore infrastructure locations in the CPA are shown in Figure 3-14 and 3-15 of the Multisale EIS. The OCS ports and infrastructure are particularly prevalent throughout coastal Louisiana. However, since most recreational use sites in Louisiana are fairly spread out, it is likely that space-use issues would not be overly pronounced. In addition, since most ocean-based recreation occurs relatively close to shore, there would more likely be conflicts with State oil and gas programs than with the CPA proposed action. Overall, the incremental contribution of the CPA proposed action to potential sources of space-use conflict should be minimal.

Oil Spills and Beach/Wetland Depletion

The OCS Program occurs in an environment in which beach and wetland resources are undergoing depletion due to human development, hurricanes, and natural processes. An overview of coastal erosion threats can be found in *Evaluation of Erosion Hazards* (The Heinz Center, 2000). Government policy towards managing beach erosion can be found at the website of NOAA's Coastal Services Center. A recent example of a proposed beach nourishment project in Panama City Beach, Florida, is presented by

COE (U.S. Dept. of the Army, COE, 2010). Oil spills have the potential to contribute to beach erosion, both due to contaminated sentiment and to the potential sediment losses during the cleanup process. This would have a particular impact on recreational activity in some of the high-volume beach areas such as Galveston and South Padre Island. However, beach cleaning techniques that are less damaging to beaches may become more prevalent during future years; a discussion of beach cleaning techniques is presented in Chapter 3.2.1.5.4 of the 2009-2012 Supplemental EIS. A more detailed discussion of the cumulative impacts of OCS actions on coastal beaches and dunes is presented in **Chapter 4.1.1.3.4**. Further information on the cumulative impacts on wetlands resources can be found in **Chapter 4.1.1.4.4**.

Deepwater Horizon *Event and Tourism*

The effects of the DWH event on tourism and recreational activity are still evolving. While a number of workers in the recreational industry were harmed, the response and mediation activities, as well as a gradually improving overall economy, have helped to put the tourism industry in the affected areas on a path to recovery. However, the DWH event will help shape public reaction to any future spills or other accidental events that occur due to offshore leasing programs on the OCS or in State waters. For example, the role of perceptions would likely be magnified in any future spill due to the significant media attention given the DWH event. On the other hand, lessons were learned from the DWH event may lessen the severity of a future spill; therefore, some effects on recreation may be lessened in the future. Lessons learned from the DWH event may also lower the probability of a future catastrophic oil spill. The cumulative impact of the CPA proposed action to these effects is small since the probability of another spill on the scale of the DWH event is quite low.

Summary and Conclusion

The CPA proposed action would contribute to low levels of aesthetic and space-use conflict with recreational activity that is expected to result cumulatively from the impacting factors. This is because much of the activities associated with the proposed action would be removed from recreational areas. Oil spills could also contribute to the overall degradation being experienced by beach and wetland-based recreational resources, but these are usually localized and small-scale events. The dynamics of any possible future large-scale oil spill would also be influenced by the damage done and lessons learned from the DWH event. However, the cumulative impact of the CPA proposed action to recreational resources is small since the incremental increase in the probability of a large spill is also low.

4.1.1.20. Archaeological Resources

The BOEMRE has reexamined the analysis for archaeological resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS. Archaeological resources are any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest (30 CFR 250.105). This Supplemental EIS is based upon additional information available since the publication of these two documents and in consideration of the DWH event. Substantial new information that alters the impact conclusion for archaeological resources presented in the Multisale EIS and the 2009-2012 Supplemental EIS has come to light as a result of BOEMRE-sponsored studies and industry surveys; specifically, reports of damage to significant cultural resources (i.e., historic shipwrecks) have been confirmed in lease areas >200 m (656 ft) deep where no survey data was available. Although the exact cause of this damage is unknown, it may be linked to postlease bottom-disturbing activities. As part of the environmental reviews conducted for postlease activities, available information will be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if mitigation is warranted.

4.1.1.20.1. Historic

4.1.1.20.1.1. Description of the Affected Environment

A detailed description of historic archaeological resources can be found in Chapter 3.3.4.1 of the Multisale EIS. Additional information for the additional 181 South Area and any new information since

the publication of the Multisale EIS is presented in Chapter 4.1.15 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

With the exception of the Ship Shoal Lighthouse structure, historic archaeological resources on the OCS consist of historic shipwrecks. A historic shipwreck is defined as a submerged or buried vessel, at least 50 years old, that has foundered, stranded, or wrecked and that is currently lying on or is embedded in the seafloor. This includes vessels that exist intact or as scattered components on or in the seafloor.

The National Park Service (NPS) and this Agency contracted three studies (CEI, 1977; Garrison et al., 1989; Pearson et al., 2003) aimed at modeling areas in the GOM where historic shipwrecks are most likely to exist. The 1977 study concluded that two-thirds of the total number of shipwrecks in the northern Gulf lie within 1.5 km (1 mi) of shore and most of the remainder lie between 1.5 and 10 km (1 and 6 mi) of the coast (CEI, 1977). The 1989 study found that changes in the late 19th- and early 20th-century sailing routes increased the frequency of shipwrecks in the open sea in the eastern Gulf to nearly double that of the central and western Gulf (Garrison et al., 1989). The Garrison study also found the highest observed frequency of shipwrecks occurred within areas of intense marine traffic, such as the approaches and entrances to seaports and the mouths of navigable rivers and straits.

Pearson et al. (2003) benefited from the experience of almost 15 years of high-resolution, shallow hazard surveys in lease blocks (a typical lease block is 9 mi^2 [5,760 ac]) and along pipeline routes. Some of these surveys (almost exclusively for pipeline routes) were conducted in deep water. Several of these pipeline hazard surveys succeeded in locating historic ships, ranging in age from an 18th-century armed sailing ship to a World War II German U-boat.

Historic shipwrecks have, to date, been discovered through oil industry sonar surveys in water depths up to 6,500 ft (1,891 m). In fact, in the last 5 years, over a dozen shipwrecks have been located in deep water and nine of these ships have been confirmed visually as historic vessels. Many of these wrecks were not previously known to exist in these areas from the historic record. Taking these discoveries into account, the 2003 study then recommended including some deepwater areas, primarily on the approach to the Mississippi River, among those lease areas requiring archaeological investigation. With this in mind, BOEMRE revised its guidelines for conducting archaeological surveys and added about 1,200 lease blocks to the list of blocks requiring an archaeological survey and assessment. These requirements are posted on the BOEMRE website under NTL 2005-G07 and NTL 2008-G20. Since implementation of these new lease blocks on July 1, 2005, at least 39 possible historic sites have been reported in this area. Recent research on historic shipping routes, moreover, suggests that the ultra-deepwater area of the Gulf of Mexico, between 25º and 27.5º N. latitude, was located along the historic Spanish trade route, which therefore increases the probability that a historic shipwreck could be located in this area (Lugo-Fernandez et al., 2007). This route runs through the proposed sale areas, and much of this area is not currently identified as requiring an archaeological assessment. A study to conduct archival research on these historic shipping routes was completed in 2010 (Krivor et al., in press) and concluded that both Spanish and French vessels were lost in the 16th, 17th, and 18th centuries while transiting the route between Vera Cruz, New Orleans, and Havana.

The BOEMRE shipwreck database currently lists 959 wrecks in the CPA (**Table 4-21**). Many of these reported shipwrecks may be considered historic and could be eligible for nomination to the National Register of Historic Places. Most of these wrecks are known only through the historical record and, to date, have not been located on the ocean floor. This list should not be considered exhaustive. Regular reporting of shipwrecks did not occur until late in the 19th century, and losses of several classes of vessels, such as small coastal fishing boats, were largely unreported in official records. There have been 34 historic wrecks positively identified in the CPA, over half of which have been found in deepwater blocks in Mississippi Canyon, Green Canyon, and Viosca Knoll. Nearly all of these have been discovered as a result of BOEMRE-mandated oil industry surveys. The discoveries include two late 18th- to early 19th-century wooden sailing vessels, one lying in nearly 2,700 ft (823 m) of water (Atauz et al., 2006) and the other in 4,000 ft (1,219 m) of water (Ford et al., 2008). There are also several World War II casualties located in deep water off the mouth of the Mississippi River (e.g., *Alcoa Puritan, GulfPenn, Halo, Virginia, Robert E. Lee*, and the German submarine U-*166*) (Church et al., 2007). All of these wrecks have been investigated using a remotely operated vehicle from a surface vessel and are in an excellent state of preservation.

Historic shipwrecks also have been identified in shallow water in the CPA. One shipwreck, the steamship *Josephine* (22HR843), currently is listed to the National Register in the CPA (Irion and Ball, 2001); a second, the Spanish American War gunboat USS *Castine*, is awaiting final listing by the Keeper of the Register.

Submerged shipwrecks off the coasts of Louisiana, Mississippi, and Alabama are likely to be moderately well preserved because of the high sediment load in the water column from upland drainage and wind and water erosion. Wrecks occurring in or close to the mouth of bays likely would have been quickly buried by transported sediment and therefore somewhat protected from the destructive effects of wood-eating shipworms (*Teredo navalis*) or storms, as has been observed at the site of *La Belle* in Matagorda Bay, Texas, and the Emanuel Point wrecks in Pensacola Bay, Florida. A good example of this type of historic wreck is the Emanuel Point Wreck, believed to be part of Spanish explorer Tristan de Luna's fleet lost in Pensacola Bay in 1559 (Smith et al., n.d.; State of Florida, Division of Historic Resources, 2010). Wrecks occurring in deeper water also have a moderate to high preservation potential. In the deep water, temperature at the seafloor is extremely cold, which slows the oxidation of ferrous metals. While the cold water at depth would eliminate the wood-eating shipworm *Teredo navalis*, it is clear from recent studies that other marine organisms consume wooden shipwrecks and that microbial organism are at work breaking down steel and iron hulls (Atauz et al., 2006; Church et al., 2007; Church and Warren, 2008; Ford et al., 2008). Deepwater shipwreck discoveries continue to be made in the CPA off the mouth of the Mississippi River.

Aside from acts of war, hurricanes cause the greatest number of wrecks in the Gulf. Wrecks occurring as a result of an extremely violent storm are more likely to be scattered over a broad area. The wreckage of the 19th-century steamer *New York*, which was destroyed in a hurricane, lies in 16 m (52 ft) of water off the coast of Mississippi and has been documented by BOEMRE (Irion and Anuskiewicz, 1999; Gearhart et al., in press) as scattered over the ocean floor in a swath over 1,500 ft (457 m) long. Shipwrecks occurring in shallow water nearer to shore are more likely to have been reworked and scattered by subsequent storms than those wrecks occurring at greater depths on the OCS. Historic research indicates that shipwrecks occur less frequently in Federal waters. These wrecks are likely to be better preserved, less disturbed, and, therefore, more likely to be eligible for nomination to the National Register of Historic Places than are wrecks in shallower State waters.

Recent hurricane activity in the Gulf of Mexico is certain to have impacted archaeological resources in shallow water. It is almost certain that any shipwrecks within the path of Hurricanes Katrina or Rita in shallow water were impacted to some extent by these storms. In September 2005, NPS conducted a study of sites along the Gulf Coast that were impacted by Hurricane Katrina (USDOI, NPS, 2005). This assessment identified three types of damage that can occur to archaeological sites: tree throws; storm surge, scouring, and erosion; and seabed shifting. On the OCS, the two primary types of damage would be associated with storm surge and seabed shifting. Damage from either of these activities could adversely affect both prehistoric and historic sites on the OCS. In early 2007, this Agency awarded a study to investigate the impacts that recent storm activity may have had on historic shipwrecks in the Gulf of Mexico. Remote-sensing surveys for this study were completed in May 2007 and dive operations were completed in October 2007. A final report of findings was submitted in 2011. Analysis of the remote-sensing surveys and diver investigations indicates that at least 3 of the 10 shipwrecks examined were affected by recent storm activity (Gearhart et al., in press). The study also concluded that older, wooden hulled vessels became less affected by recent storm events after having settled into an equilibrium within their environment, despite being periodically exposed and reburied.

4.1.1.20.1.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of routine impacts for the CPA proposed action on historic archaeological resources can be found in Chapter 4.2.1.1.12 of the Multisale EIS and in Chapter 4.1.15.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

This section discusses the possible effects of routine activities associated with the CPA proposed action on archaeological resources. Routine impact-producing factors associated with the CPA proposed action that could affect historic archaeological resources include the direct physical contact with a shipwreck site; the placement of drilling rigs and production systems on the seafloor; pile driving associated with platform emplacement; pipeline placement; dredging of new channels, as well as maintenance dredging of existing channels; anchoring activities; pipeline installation; structure removals and site clearance; and the masking of archaeological resources from industry-related debris.

Several OCS-related, impact-producing factors may cause adverse impacts to historic archaeological resources. Offshore development could result in a drilling rig, platform, pipeline, dredging activity, or anchors having an impact on a historic shipwreck. Direct physical contact with a wreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the period from which the ship dates. Industry-related impacts have been found to have occurred in areas where remote-sensing surveys had not been previously required (Atauz et al., 2006; Church and Warren, 2008). Remote-sensing surveys of the seafloor using high-resolution sidescan sonar and magnetometers have been found to be an effective means of locating historic submerged properties in order to avoid impacts from the undertaking.

The placement of drilling rigs and production systems has the potential to cause physical impact to prehistoric and/historic archaeological resources. The area of seafloor disturbance from each of these structures is defined in **Chapter 3.1.1.2**. Pile driving associated with platform emplacement may also cause sediment liquefaction an unknown distance from the piling, disrupting stratigraphy in the area of liquefaction.

According to estimates presented in **Table 3-2**, 403-697 exploration, delineation, development, and production wells would be drilled and 32-44 production platforms would be installed in support of the proposed action. Of these, 111-155 exploration, delineation, development and production wells would be drilled, and 22-28 platforms would be installed in water depths of 200 m (656 ft) or less, where the majority of blocks having the highest potential for historic period shipwrecks are located. The location of any proposed activity within a lease that has a high potential for historic shipwrecks requires archaeological clearance prior to operations. While the expanded BOEMRE shipwreck database contains 911 reported shipwrecks in the entire CPA (**Table 4-21**), this number is believed to represent a fraction of the actual number of ships lost in the CPA. Recent research on historic shipping routes, moreover, suggests that the ultra-deepwater area of the Gulf of Mexico, between 25º and 27.5º N. latitude, was located along the historic Spanish trade route, which therefore increases the probability that a historic shipwreck could be located in this area (Lugo-Fernandez et al., 2007). This route runs through the proposed sale area, and much of this area had not previously been identified as requiring an archaeological assessment. A study to conduct archival research on these historic shipping routes was completed in 2010 (Krivor et al., in press) and concluded that both Spanish and French vessels were lost in the 16th, 17th, and 18th centuries while transiting the route between Vera Cruz, New Orleans, and Havana. In addition, discoveries made since 2005 in newly surveyed deepwater lease blocks in the CPA suggest that shipwrecks may occur anywhere on the OCS, and the ability to predict their specific locations offshore in the Gulf of Mexico based on a review of historic literature is limited. Of the 12,409 lease blocks in the CPA, less than 40 percent (4,686) are leased. There are 2,332 blocks that fall within the Gulf of Mexico Region's current high-potential areas for historic resources in the CPA. Of these blocks, 812 are in water depths of 200 m (656 ft) or less and would require a survey at 50-m linespacing. There are 1,520 blocks in water depths that preclude a survey with a magnetometer and require sidescan-sonar survey at no more than a 300-m linespacing. The potential of an interaction between rig or platform emplacement and a historic shipwreck is greatly diminished by site surveys. In certain circumstances, the Regional Director may require the preparation of an archaeological report to accompany the EP, DOCD, or DPP, under 30 CFR 250.194. As part of the environmental reviews conducted for postlease activities, available information would be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if mitigation is warranted.

Pipeline placement has the potential to cause a physical impact to prehistoric and/or historic archaeological resources. Pipelines placed in water depths of less than 200 ft (61 m) must be buried. Burial depths of 3 ft (1 m) are required, with the exception of shipping fairways and anchorage areas, where the requirements are 10 ft (3.1 m) and 15 ft (4.6 m), respectively.

Maintenance dredging in support of activities resulting from the proposed action has the potential to impact a historic shipwreck. Impacts from maintenance dredging can be attributed proportionally to the users of the navigation channels. The BOEMRE assessment indicates that, under the proposed action, <1 percent of the ship traffic is related to OCS use. Therefore, the impact to archaeological sites directly attributable to traffic and maintenance dredging as a result of the OCS Program is negligible. Proposed action activities represent <1 percent of the usage of the major navigation channels for the CPA.

Anchoring associated with platform and pipeline emplacement, as well as with service-vessel and shuttle-tanker activities, may also physically impact prehistoric and/or historic archaeological resources. It is assumed that, during pipeline emplacement, an array of eight 20,000-lb anchors is continually repositioned around the pipelaying barge.

Activities resulting from the proposed action would generate ferromagnetic structures and debris, which would tend to mask magnetic signatures of significant historic archaeological resources. The task of locating historic resources through an archaeological survey is, therefore, made more difficult as a result of leasing activity.

Explosive seismic charges set off near historic shipwrecks may displace the surrounding sediments and cause loss of archaeological information regarding the context of the site. Furthermore, damage may result to the associated artifact assemblage.

Archaeological surveys are assumed to be effective in reducing the potential for an interaction between an impact-producing activity and a historic resource. The surveys are expected to be most effective in areas where there is only a thin veneer of unconsolidated Holocene sediments. In these areas, shipwreck remains are more likely to be exposed at the seafloor where they can be detected by the side-scan sonar as well as the magnetometer. In areas of thicker unconsolidated sediments, shipwreck remains are more likely to be completely buried, with detection relying solely on recording an anomalous perturbation of the ambient magnetic field. With sites that are buried, and therefore more difficult to identify, the preservation potential is higher; thus, the potential for significant archaeological data is also higher. At the current survey linespacing requirement of 50 m, studies have concluded that a sizeable portion of shipwrecks would be detected on at least one survey line (Garrison et al., 1989; Enright et al., 2006, p. 129). By the same token, however, “small wooden-hulled vessels, whether machine- or sail-powered, are unlikely to be detected by 300-m (984-ft) surveys in most instances” (Enright et al., 2006, p. 129). In the CPA, 1,802 lease blocks are designated as having a high potential for containing submerged prehistoric sites, but a low potential for historic shipwrecks and are surveyed at a 300-m survey interval. In the CPA, 1,520 deepwater (>200 m; 656 ft) lease blocks, designated as having a high probability for containing shipwrecks, are beyond the practical range of magnetometers and are surveyed at 300-m linespacing using sidescan sonar.

Summary and Conclusion

The greatest potential impact to an archaeological resource as a result of the CPA proposed action would result from direct contact between an offshore activity (i.e., platform installation, drilling rig emplacement, and dredging or pipeline project) and a historic site. Archaeological surveys, where required prior to an operator beginning oil and gas activities on a lease, are expected to be effective at identifying possible archaeological sites. The technical requirements of the archaeological resource reports are detailed in NTL 2005-G07, “Archaeological Resource Surveys and Reports.” Under 30 CFR 250.194(c) and 30 CFR 250.1010(c), lessees are required to notify this Agency immediately of the discovery of any potential archaeological resources.

Offshore oil and gas activities resulting from the proposed action could impact an archaeological resource because of incomplete knowledge on the location of these sites in the Gulf. The risk of contact to archaeological resources is greater in instances where archaeological survey data are unavailable. Such an event could result in the disturbance or destruction of important archaeological information. Archaeological surveys, where required, would provide the necessary information to develop avoidance strategies that would reduce the potential for impacts on archaeological resources.

Except for the projected 0-1 new gas processing plants and 0-1 new pipeline landfall, a CPA proposed action would require no new oil and gas coastal infrastructure. It is expected that archaeological resources would be protected through the review and approval processes of the various Federal, State, and local agencies involved in permitting onshore activities.

4.1.1.20.1.3. Impacts of Accidental Events

Background/Introduction

A detailed impact analysis of the possible effects of accidental impacts associated with the proposed WPA lease sale on historic archaeological resources can be found in Chapter 4.4.13.1 of the Multisale EIS and in Chapter 4.1.15.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Impacts to a historic archaeological resource could occur as a result of an accidental spill. A major effect from an oil-spill impact would be visual contamination of a historic coastal site, such as a historic fort or lighthouse. Such effects would be temporary and reversible. The use of dispersants, however, could result in chemical contamination of submerged cultural heritage sites. The effect, if any, of chemical dispersant use at the Macondo well site in 2010 on submerged shipwrecks is still not known. It is known that there are at least seven historically significant sites within 20 mi (32 km) of the well site. A recent site investigation of corals approximately 7 mi (11 km) from the Macondo well site revealed that the corals were impacted by the oiling event. "Here is a lot of dead coral, dying coral, dying associates, even a dead golden crab in the field. Much of the coral is covered by what looks like oily gunk" (Fisher, personal communication, 2010). This has implications for the oiling of shipwreck sites and the microbiological organisms that are consuming these steel-hulled vessels. According to Church et al., the observed bioaccumulation of oxidized forms of iron at the site of *Alcoa Puritan*, generated by microbial activity in 2004 (located 12 mi [19 km] from the Macondo wellhead), was parallel to the degradation of the remains of RMS *Titanic* (Church et al., 2007, p. 205). This microbial activity may have been accelerated or retarded by compounds and elements associated with the release of millions of gallons of hydrocarbons in the water column. Currently, little information is known about the impacts of microbial activity on wooden shipwreck sites in deep water, and further study is warranted for both wooden shipwrecks and steel-hulled vessels to properly assess the impacts on these historically significant archaeological resources.

Other impacts that remain unknown at this time include the effect that the oiling of archaeological resources would have on the ability to conduct future chemical and observational analysis on the artifact assemblage. Currently, it is unknown if the release of hydrocarbons or of dispersant would impede the analysis that may help interpret and understand archaeological resources.

The major impacts to both coastal historic and prehistoric sites from the *Exxon Valdez* spill in Alaska in 1989 were related to cleanup activities such as the construction or helipads, roads, and parking lots and to looting by cleanup crews rather than from the oil itself (Bittner, 1996). As a result, cultural resources were recognized as significant early in the response to the DWH event, and archaeologists were embedded in SCAT's and were consulting with cleanup crews. Although the process took several weeks to fully form, historic preservation representatives eventually were stationed at both the Joint Incident Command as well as each Area Command under the general oversight of the National Park Service to coordinate response efforts (Odess, personal communication, 2010).

Summary and Conclusion

Accidental events producing oil spills may threaten archaeological resources along the Gulf Coast. Should a spill contact a historic archaeological site (including submerged sites), damage might include direct impact from oil-spill cleanup equipment, contamination of materials, and/or looting. The major effect from an oil-spill impact would be visual contamination of a historic coastal site, such as a historic fort or lighthouse. It is expected that any spill cleanup operations would be considered a Federal action

for the purposes of Section 106 of the NHPA and would be conducted in such a way as to cause little or no impacts to historic archaeological resources. Recent research suggests the impact of direct contact of oil on historic properties may be long term and not easily reversible without risking damage to fragile historic materials (Chin and Church, 2010). Previously unrecorded sites could be impacted by oil-spill cleanup operations on beaches and offshore. As indicated in Chapter 4.3.1.8 of the Multisale EIS, it is not very likely for an oil spill to occur and contact submerged, coastal or barrier island historic sites as a result of the CPA proposed action.

The potential for spills is low, the effects would generally be temporary and localized, and the cleanup efforts would be regulated. The proposed action, therefore, is not expected to result in impacts to historic archaeological sites; however, should such an impact occur, unique or significant archaeological information could be lost and this impact could be irreversible.

4.1.1.20.1.4. Cumulative Impacts

An impact analysis for cumulative impacts in the CPA on historic archaeological resources can be found in Chapter 4.5.14.1 of the Multisale EIS and in Chapter 4.1.15.4 of the 2009-2012 Supplemental EIS.

Of the cumulative scenario activities, those that could potentially impact historic archaeological resources include the following: (1) the OCS Program; (2) State oil and gas activity; (3) maintenance dredging; (4) OCS sand borrowing; (5) artificial rigs-to-reef development; (6) offshore LNG projects; (7) renewable energy and alternative use conversions; (8) commercial fishing; (9) sport diving and commercial treasure hunting, and (10) hurricanes.

Archaeological surveys are assumed to be highly effective in reducing the potential for an interaction between an impact-producing activity and a historic resource. The surveys are expected to be most effective in areas where there is only a thin veneer of unconsolidated Holocene sediments. In these areas, shipwreck remains are more likely to be exposed at the seafloor where they can be detected by the side-scan sonar as well as the magnetometer. In areas of thicker unconsolidated sediments, shipwreck remains are more likely to be completely buried with detection relying solely on magnetometer.

According to estimates presented in Table 4-4 of the Multisale EIS, an estimated 38,677-45,338 exploration, delineation, and development wells would be drilled, and 2,958-3,262 production platforms would be installed as a result of the OCS Program. Of this range, between 19,840 and 22,216 exploration, delineation, and development wells would be drilled, and 2,779-2,991 production structures would be installed in water depths of 200 m (656 ft) or less. The majority of lease blocks in this water depth have a high potential for historic shipwrecks. Archaeological surveys were first required for Lease Sale 32 held in December 1973; therefore, it is assumed that any major impacts to historic resources that may have occurred resulted from development prior to this time.

Of the 17,649 lease blocks in the OCS Program area, less than half of these blocks are leased. There are 2,938 blocks that fall within the Gulf of Mexico Region's high-potential areas for historic resources. Of these blocks, 1,395 blocks are in water depths of 200 m (656 ft) or less and would require a survey at 50-m linespacing. The potential of an interaction between MODU or platform emplacement and a historic shipwreck is greatly diminished by requisite site surveys, but it still exists. Such an interaction could result in the loss of or damage to significant or unique historic resources.

Table 4-4 of the Multisale EIS indicates that the placement of between 9,470 and 66,550 km (5,884-41,352 mi) of pipelines is projected in the cumulative activity area. While the required archaeological survey minimizes the chances of impacting a historic shipwreck, there remains a possibility that a wreck could be impacted by pipeline emplacement. Such an interaction could result in the loss of significant or unique historic resources.

The setting of anchors for drilling rigs, platforms, and pipeline lay barges, and anchoring associated with oil and gas service-vessel trips to the OCS have the potential to impact historic wrecks. Archaeological surveys serve to minimize the chance of impacting historic wrecks; however, these surveys are not infallible and the chance of an impact from future activities does exist. Impacts from anchoring on a historic shipwreck may have occurred. There is also a potential for future impacts from anchoring on a historic shipwreck. Such an interaction could result in the loss of or damage to significant or unique historic resources and the scientific information they contain.

The probabilities of offshore oil spills ≥1,000 bbl occurring from OCS Program activities is presented in **Chapter 3.1.1.3**. Oil spills have the potential to impact coastal historic sites directly or indirectly by physical impacts caused by oil-spill cleanup operations. The impacts caused by oil spills to coastal historic archaeological resources are generally short term and reversible. **Table 4-22** presents the coastal spill scenario from both OCS and non-OCS sources. It is assumed that the majority of the spills would occur around terminals and be contained in the vicinity of the spill. Should such oil spills contact a historic site, the effects would be temporary and reversible.

Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high potential for historic shipwrecks; the greatest concentrations of historic wrecks are likely associated with these features (Pearson et al., 2003). It is reasonable to assume that significant or unique historic archaeological information has been lost as a result of past channel dredging activity. In many areas, COE requires remote-sensing surveys prior to dredging activities to minimize such impacts.

Past, present, and future OCS oil and gas exploration and development and commercial trawling would result in the deposition of tons of ferromagnetic debris on the seafloor. Modern marine debris associated with these activities would tend to mask the magnetic signatures of historic shipwrecks, particularly in areas that were developed prior to requiring archaeological surveys. Such masking of the signatures characteristic of historic shipwrecks may have resulted or may yet result in OCS activities in the cumulative activity area impacting a shipwreck containing significant or unique historic information.

State oil and gas program wells, structures, and pipelines in State waters are not under the jurisdiction of BOEMRE with respect to the archaeological resource protection requirements of the NHPA. However, other Federal agencies, such as COE, which issues permits associated with pipelines in State waters, are responsible for the protection of archaeological resources under the NHPA. Therefore, the impacts that might occur to archaeological resources by pipeline construction originating from OCS-related activity within State waters should be mitigated under the requirements of the NHPA, and the same archaeological surveys for planned pipelines that lead into a landfall or a tie-in to a pipeline in State waters are required. Prior to 1989, it is possible that explosive seismic surveys on the OCS and within State waters could have impacted historic shipwrecks. Explosive seismic charges set near historic shipwrecks could have displaced the vessel's surrounding sediments, acting like a small underwater fault and moving fragile wooden, ceramic, and metal remains out of their initial cultural context. Such an impact would have resulted in the loss of significant or unique archaeological information.

Maintenance dredging takes place in existing, often well-used, and marked seaways and transit corridors within which any historic wrecks would have been already disturbed or their historical context destroyed. Most channel dredging occurs at the entrances to bays, harbors, and ports. These areas have a high potential for historic shipwrecks; the greatest concentrations of historic wrecks are likely associated with these features (Pearson et al., 2003). It is reasonable to assume that significant or unique historic archaeological information has been lost as a result of past channel dredging activity. In many areas, COE requires remote-sensing surveys prior to dredging activities to minimize such impacts. Routine maintenance dredging, as an ongoing activity in well-plied channels, is not likely to result in any new disturbance or disruption to historic wrecks.

The OCS sand borrowing is expected to be an activity on the increase during the OCS cumulative activities period. Approximately 76 million yd^3 of OCS sand is liable to be accessed for coastal restorations over the next 5-10 years from Ship Shoal Blocks 88 and 89 and from South Pelto Blocks 12 and 13, primarily. For these bottom-disturbing activities, a preconstruction archaeological survey is required by BOEMRE for the borrow site lease. No new disturbance of historic shipwrecks would be expected when a predeployment archaeological survey of sand borrow sites is first examined for sea-bottom anomalies by BOEMRE so that the proper setback distances can be required that allow potential resources to be avoided.

Artificial reef development, offshore LNG projects, and renewable energy projects and alternative use conversions are expected to remain at, respectively, a steady pace of activity, to decrease, and to increase as competing uses of the OCS. A preconstruction archaeological survey is required before bottom-disturbing activities are permitted for artificial reef emplacement (if not reefed on site), deepwater ports for LNG facilities, and newly built renewable energy facilities. Alternative-use conversions of existing infrastructure likely would not involve new bottom-disturbing activities, but if called for in applications, a preconstruction survey would be required. No new disturbance of historic shipwrecks would be expected when predeployment archaeological surveys are first examined for sea-bottom anomalies by BOEMRE,

or the permitting agency, so that proper setback distances can be required that allow mitigation potential resources to be avoided.

Commercial fishing trawling activity specifically would only affect the uppermost portions of the sediment column (Garrison et al., 1989) in water depths generally <600 ft (183 m). On many wrecks, the uppermost portions would already be disturbed by natural factors and would contain only artifacts that have lost all original context.

Sport diving, which is generally restricted to water depths <130 ft (40 m), and commercial treasure hunting are significant factors in the loss of historic data from wreck sites. Efforts to educate sport divers and to foster the protection of historic shipwrecks, such as those of the Florida Keys National Marine Sanctuary and the Florida Public Archaeology Network, serve to lessen these potential impacts. While commercial treasure hunters generally impact wrecks with intrinsic monetary value, sport divers may collect souvenirs from all types of wrecks within their diving limits. Since the extent of these activities is unknown, the impact cannot be quantified. A Spanish war vessel, *El Cazador*, was discovered in the CPA; it contained a large amount of silver coins and has been impacted by treasure hunting salvage operations (McLaughlin, 1995). The historic data available from this wreck and from other wrecks that have been impacted by treasure hunters and sport divers represent a significant or unique loss.

Hurricanes and tropical storms are normal occurrences in the GOM and along the Gulf Coast. On average, 15-20 hurricanes make landfall along the northern Gulf Coast per decade. Shipwrecks in shallow waters are exposed to a greatly intensified, longshore current during tropical storms (Clausen and Arnold, 1975). Under such conditions, it is highly likely that artifacts (e.g., ceramics and glass) would be dispersed. Some of the original information contained in the site would be lost in this process, but a significant amount of information would also remain. Overall, a significant loss of data from historic sites has probably occurred, and will continue to occur, in the northeastern Gulf from the effects of tropical storms. Some of the data lost have most likely been significant or unique.

Summary and Conclusion

Several impact-producing factors may threaten historic archaeological resources, all related to bottom-disturbing activities. An impact could result from contact between a historic shipwreck located on the OCS and OCS Program or State oil and gas activities (i.e., pipeline and platform installations, drilling rig emplacement and operation, dredging, anchoring activities, structure removal, and site clearance). Bottom-disturbing activities on the OCS also include maintenance dredging, sand borrowing, transported artificial reef emplacement, LNG facility construction, and renewable energy facility construction. With the exception of maintenance dredging, preconstruction surveys may be required by BOEMRE or the permitting agency. Impacts resulting from the imperfect knowledge of the location of historic resources may still occur in areas where a high-resolution survey is only required at 300-m (98-ft) survey intervals. The OCS development prior to requiring archaeological surveys has been documented to have impacted wrecks containing significant or unique historic information. This was amply demonstrated when a pipeline was laid across a previously unknown early 19th-century shipwreck and when an MODU mooring anchor chain cut a shipwreck in half (Atauz et al., 2006; Church and Warren, 2008). The archaeological resources regulation at 30 CFR 250.194 grants authority in certain cases to each BOEMRE Regional Director to require archaeological reports to be submitted with the EP, DOCD, or DPP where deemed necessary. As part of the environmental reviews conducted for postlease activities, available information will be evaluated regarding the potential presence of archaeological resources within the proposed action area to determine if mitigation is warranted.

The loss or discard of ferromagnetic debris associated with oil and gas exploration and development and trawling activities could result in the masking of historic shipwrecks or the identification of false negatives on archaeological surveys (an anomaly that does not appear to be of historical significance, but actually is).

Damage to or loss of significant or unique historic archaeological information from commercial fisheries (trawling) is highly likely in water depths <600 ft (183 m) (Foley, 2010). It is expected that maintenance dredging, commercial bottom trawling, sport-diving and commercial treasure hunting, and hurricanes and tropical storms have impacted and would continue to impact historic period shipwrecks on the shelf where such activities occur.

Development onshore as a result of the proposed action could result in the direct physical contact between a historic site and pipeline trenching. It is assumed that archaeological investigations prior to construction would serve to mitigate these potential impacts. The expected effects of oil spills on historic coastal resources are temporary and reversible.

The effects of the various impact-producing factors discussed in this analysis have likely resulted in the loss of significant or unique historic archaeological information. In the case of factors related to OCS Program activities of the past within the cumulative activity area, it is reasonable to assume that most impacts would have occurred prior to 1973 (the date of initial archaeological survey and site-clearance requirements). Future OCS Program activities and the bottom-disturbing activities permitted by BOEMRE and other agencies may require preconstruction archaeological surveys that, when completed, are highly effective in identifying bottom anomalies that could be avoided or investigated before bottom-disturbing activities begin. When surveys are not required, it is impossible to anticipate what might be imbedded in or lying directly on the seafloor, and impacts to these sites are likely to be major in scale. Despite diligence in site-clearance survey reviews, there is still the possibility of an unanticipated interaction between bottom-disturbing activity (i.e., rig emplacement, pipeline trenching, anchoring, and other ancillary activities) and a historic shipwreck. The incremental contribution of the proposed action is expected to be very small due to the efficacy of the remote-sensing surveys and archaeological reports, where required.

4.1.1.20.2. Prehistoric

4.1.1.20.2.1. Description of the Affected Environment

A detailed description of prehistoric archaeological resources can be found in Chapter 3.3.4.2 of the Multisale EIS. Additional information for the additional 181 South Area and any new information since the publication of the Multisale EIS is presented in Chapter 4.1.15 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Available evidence suggests that sea level in the northern GOM was at least 90 m (295 ft), and possibly as much as 130 m (427 ft), lower than present sea level during the period 20,000-17,000 years B.P. (Nelson and Bray, 1970). Sea level in the northern Gulf reached its present stand around 3,500 years B.P. (Pearson et al., 1986).

During periods that the continental shelf was exposed above sea level, the area was open to habitation by prehistoric peoples. The advent of early man into the GOM region is currently accepted to be around 12,000 years B.P. (Aten, 1983). The sea-level curve for the northern GOM proposed by Coastal Environments, Inc. (CEI) suggests that sea level at 12,000 years B.P. would have been approximately 45-60 m (148-197 ft) below the present-day sea level (CEI, 1977 and 1982). On this basis, the continental shelf shoreward of the 45- to 60-m (148- to 197-ft) bathymetric contours has potential for prehistoric sites dating after 12,000 years B.P. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, this Agency adopted the 60-m (197-ft) water depth as the seaward extent for archaeological site potential in the GOM region.

Based on their 1977 baseline study, CEI (1977) proposed that sites analogous to the types of sites frequented by Paleo-Indians can be identified on the now-submerged shelf. Geomorphic features that have a high potential for associated prehistoric sites include barrier islands and back-barrier embayments, river channels and associated floodplains and terraces, and salt-dome features. Remote-sensing surveys have been very successful in identifying these types of geographic features, which have a high potential for associated prehistoric sites. Recent investigations in Louisiana and Florida indicate the mound-building activity by prehistoric inhabitants may have occurred as early as 6,200 years B.P. (cf. Haag, 1992; Saunders et al., 1992; Russo, 1992). Therefore, manmade features, such as mounds, may also exist in the shallow inundated portions of the OCS.

Regional geological mapping studies by BOEMRE allow interpretations of specific geomorphic features and assessments of archaeological potential in terms of age, the type of system the geomorphic features belong to, and geologic processes that formed and modified them. The potential for site preservation must also be considered as an integral part of the predictive model. In general, sites protected by sediment overburden have a high potential for preservation from the destructive effects of

marine transgression. The same holds true for sites submerged in areas subjected to low wave energy and for sites on relatively steep shelves, which were inundated during periods of rapid rise in sea level. Although many specific areas in the Gulf having a high potential for prehistoric sites have been identified through archaeological surveys, industry generally has chosen to avoid these areas rather than conduct further investigations.

Surveys from other areas of the western part of the CPA have produced evidence of floodplains, terracing, and point-bar deposits in association with relict late Pleistocene fluvial systems. Prehistoric sites associated with these features would have a high potential for preservation. Salt diapirs with bathymetric expression have also been recorded during lease-block surveys in this area. Solution features at the crest of these domes would have a high potential for preservation of associated prehistoric sites. The Salt Mine Valley site on Avery Island is a Paleo-Indian site associated with a salt-dome solution feature (CEI, 1977). The proximity of most of these relict landforms to the seafloor facilitates further investigation and data recovery.

The Holocene history of southeastern Louisiana is extremely complex and characterized by overlapping deltaic lobes. Prehistoric terrestrial sites inhabited during active buildout of the old deltas and during early stages of their deterioration can be anticipated in shallow shelf areas. A large number of prehistoric sites have likely been encapsulated in the alluvial deposits of older deltaic lobes but through a combination of subsidence, and rapid deposition could be buried by as much as 300 ft (91 m) of Holocene sediment.

A good-faith effort was made to identify any impacts to known prehistoric sites in the Central GOM as a result of recent hurricane activity; however, no such information was identified. It is unlikely that Hurricane Katrina would have affected any prehistoric sites on the OCS because of the deep burial of the Pleistocene surface.

4.1.1.20.2.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of the possible effects of routine impacts associated with the CPA proposed action on prehistoric archaeological resources can be found in Chapter 4.2.1.1.12.2 of the Multisale EIS and in Chapter 4.1.15.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared

Proposed Action Analysis

Blocks with a high potential for prehistoric archaeological resources are found landward of the 12,000-years-B.P. shoreline position, which is roughly approximated by the last geologic still-stand before inundation at approximately 13,000 years B.P. This 13,000-years-B.P. still-stand also roughly follows the 45-m (148-ft) bathymetric contour. Because of inherent uncertainties in both the depth of historic sea-level stands and the entry date of prehistoric man into North America, BOEMRE has adopted the 60-m (197-ft) water depth as the seaward extent of the area considered to have potential for prehistoric archaeological resources.

Offshore development as a result of the CPA proposed action could result in an interaction between a drilling rig, platform, pipeline, dredging activity, or anchors and an inundated prehistoric site. This direct physical contact with a site could destroy fragile artifacts or site features and could disturb artifact provenance and site stratigraphy. The result would be the loss of archaeological data on prehistoric migrations, settlement patterns, subsistence strategies, and archaeological contacts for North America, Central America, South America, and the Caribbean.

The placement of drilling rigs and production systems has the potential to cause physical impact to prehistoric archaeological resources. Pile driving associated with platform emplacement may also cause sediment liquefaction an unknown distance from the piling, disrupting stratigraphy in the area of liquefaction.

Pipeline placement has the potential to cause a physical impact to prehistoric archaeological resources. Pipelines placed in water depths of <60 m (200 ft) must be buried. Burial depths of 3 ft (1 m) are required, with the exception of shipping fairways and anchorage areas, where the requirements are 10

ft (3.1 m) and 15 ft (4.6 m), respectively. Anchoring associated with platform and pipeline emplacement, as well as with service-vessel and shuttle-tanker activities, may also physically impact prehistoric archaeological resources. It is assumed that, during pipeline emplacement, an array of eight 20,000-lb anchors is continually repositioned around the pipelaying barge.

Onshore prehistoric archaeological resources include sites, structures, and objects such as shell middens, earth middens, campsites, kill sites, tool manufacturing areas, ceremonial complexes, and earthworks. Prehistoric sites that have yet to be identified would have to be assessed after discovery to determine the uniqueness or significance of the information that they contain. Sites already listed in the National Register of Historic Places and those considered eligible for the Register have already been evaluated as having the potential for making a unique or significant contribution to science. Of the unidentified coastal prehistoric sites that could be impacted by onshore development, some may contain unique information.

Onshore development as a result of the proposed action could result in direct physical contact between construction of new onshore facilities or a pipeline landfall and a previously unidentified prehistoric site. Direct physical contact with a prehistoric site could destroy fragile artifacts or site features and could disturb the site context. The result would be the loss of information on the prehistory of North America and the Gulf Coast region.

Since all platform locations within the high-potential areas for the occurrence of offshore prehistoric archaeological resources are given archaeological clearance prior to setting the structure, removal of the structure should not result in any adverse impact to archaeological resources. This is consistent with the findings of the *Programmatic Environmental Assessment: Structure Removal Activities, Central and Western Gulf of Mexico Planning Areas* (USDOI, MMS, 1987).

Except for the projected 0-1 new gas processing plant and 0-1 new pipeline landfall, the proposed action would require no new oil and gas coastal infrastructure. Any facility constructed must receive approval from the pertinent Federal, State, county, and community involved. Protection of archaeological resources in these cases is expected to be achieved through the various approval processes involved. There should, therefore, be no impact to onshore prehistoric sites from onshore development related to the proposed action.

In order to reduce the risk of impacting a prehistoric archaeological resource during a BOEMRE-permitted activity, BOEMRE requires a 300-m (984-ft), remote-sensing survey linespacing for lease blocks that have been identified as having a high potential for containing prehistoric resources. The current NTL—NTL 2005-G07, effective July 1, 2005—supersedes all other archaeological NTL's and Letters to Lessees and Operators, and it clarifies the updated information to reflect current technology. The list of lease blocks requiring an archaeological survey and assessment are identified in NTL 2008-G20.

Summary and Conclusion

The greatest potential impact to an archaeological resource as a result of a CPA proposed action would result from direct contact between an offshore activity (i.e., platform installation, drilling rig emplacement, and dredging or pipeline project) and a prehistoric site. Prehistoric archaeological sites are thought potentially to be preserved shoreward of the 45-m (148-ft) bathymetric contour, where the Gulf of Mexico continental shelf was subaerially exposed during the Late Pleistocene. The archaeological survey, where required prior to an operator beginning oil and gas activities on a lease, is expected to be somewhat effective at identifying submerged landforms that could support possible archaeological sites. NTL 2005-G07 suggests a 300-m (984-ft) linespacing for remote-sensing surveys of leases within areas having a high potential for prehistoric sites. While surveys provide a reduction in the potential for a damaging interaction between an impact-producing factor and a prehistoric archaeological site, there is a possibility of an OCS activity contacting an archaeological site because of an insufficiently dense survey grid. Should such contact occur, there would be damage to or loss of significant and/unique archaeological information. Except for the projected 0-1 new gas processing plants and 0-1 new pipeline landfall, a CPA proposed action would require no new oil and gas coastal infrastructure. It is expected that archaeological resources would be protected through the review and approval processes of the various Federal, State, and local agencies involved in permitting onshore activities.

4.1.1.20.2.3. Impacts of Accidental Events

Background/Introduction

A detailed impact analysis of the possible effects of accidental impacts associated with the CPA proposed action on prehistoric archaeological resources can be found in Chapter 4.4.13.2 of the Multisale EIS and in Chapter 4.1.15.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Impacts to a prehistoric archaeological resource could occur as a result of an accidental spill. A major effect from an oil-spill impact would be visual contamination of a historic coastal site, such as a historic fort or lighthouse. Such effects would be temporary and reversible. The use of dispersants, however, could result in chemical contamination of submerged cultural heritage sites. The effect, if any, of chemical dispersant use at the Macondo well site on submerged shipwrecks is still not known. The major impacts to both coastal historic and prehistoric sites from the *Exxon Valdez* spill in Alaska in 1989 were related to cleanup activities such as the construction of helipads, roads, and parking lots and to looting by cleanup crews rather than from the oil itself (Bittner, 1996). As a result, cultural resources were recognized as significant early in the response to the DWH event, and archaeologists were embedded in SCAT's and were consulting with cleanup crews. Although the process took several weeks to fully form, historic preservation representatives eventually were stationed at both the Joint Incident Command as well as each Area Command under the general oversight of the National Park Service to coordinate response efforts (Odess, personal communication, 2010).

Summary and Conclusion

Accidental events producing oil spills may threaten archaeological resources along the Gulf Coast. Should a spill contact a prehistoric archaeological site, damage might include loss of radiocarbon-dating potential, direct impact from oil-spill cleanup equipment, and/or looting. Previously unrecorded sites could be impacted by oil-spill cleanup operations on beaches. As indicated in Chapter 4.3.1.8 of the Multisale EIS, it is not very likely for an oil spill to occur and contact coastal and barrier island prehistoric sites as a result of a CPA proposed action. The proposed action, therefore, is not expected to result in impacts to prehistoric archaeological sites.

4.1.1.20.2.4. Cumulative Impacts

An impact analysis for cumulative impacts in the CPA on prehistoric archaeological resources can be found in Chapter 4.5.14.2 of the Multisale EIS and in Chapter 4.1.15.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Future OCS exploration and development activities in the Gulf of Mexico between 2007 and 2046, which can be found in Table 4-4 of the Multisale EIS, projects drilling 12,966-14,187 exploration, delineation, and development wells in water depths <60 m (197 ft). Relative sea-level curves for the Gulf of Mexico indicate there is no potential for the occurrence of prehistoric archaeological sites in water depths greater than 60 m (197 ft). Archaeological surveys are assumed to be highly effective in reducing the potential for an interaction between an impact-producing activity and a prehistoric resource. Archaeological surveys were first required for Lease Sale 32 held in December 1973; therefore, it is assumed that the major impacts to prehistoric resources that may have occurred resulted from development prior to this time. The potential of an interaction between rig or platform emplacement and a prehistoric site is diminished by the survey, but it still exists. Such an interaction would result in the loss of or damage to significant or unique prehistoric information.

The placement of 2,980-22,110 km (1,852-13,739 mi) and 2,340-9,580 km (1,454-5,953 mi) of pipelines in water depths <60 m (197 ft) is projected as a result OCS Program activities in the CPA and

WPA, respectively. For the OCS Program, 5,320-31,690 km (5,320-19,691 mi) of pipelines are projected in water depths <60 m (197 ft). While archaeological surveys minimize the chances of impacting a prehistoric site, there remains a possibility that a site could be impacted by pipeline emplacement. Such an interaction would result in the loss of significant or unique archaeological information.

The setting of anchors for drilling rigs, platforms, and pipeline lay barges, and anchoring associated with oil and gas service-vessel trips to the OCS have the potential to impact shallowly buried prehistoric sites. Archaeological surveys minimize the chance of impacting these sites; however, these surveys are not seen as infallible, and the chance of an impact from future activities exists. Impacts from anchoring on a prehistoric site may have occurred. Such an interaction could result in the loss of significant or unique archaeological information.

The probabilities of offshore oil spills ≥1,000 bbl occurring from the OCS Program in the cumulative activity area is presented in **Chapter 3.3**. Oil spills have the potential to impact coastal prehistoric sites directly or indirectly by physical impacts caused by oil-spill cleanup operations. Coastal, oil-spill scenario numbers are presented in Table 4-13 of the Multisale EIS for both OCS and non-OCS sources. It is assumed that the majority of the spills would occur around terminals and would be contained in the vicinity of the spill. There is a small possibility of these spills contacting a prehistoric site. The impacts caused by oil spills to coastal prehistoric archaeological resources can severely distort information relating to the age of the site. Contamination of the organic site materials by hydrocarbons can make radiocarbon dating of the site more difficult or even impossible. This loss might be ameliorated by using artifact seriation or other relative dating techniques. Coastal prehistoric sites might also suffer direct impact from oil-spill cleanup operations as well as looting resulting from interactions between persons involved in cleanup operations and unrecorded prehistoric sites. Interaction between oil-spill cleanup equipment or personnel and a site could destroy fragile artifacts or disturb site context, possibly resulting in the loss of information on the prehistory of North America and the Gulf Coast region. Some coastal sites may contain significant or unique information.

Most channel dredging occurs at the entrances to bays, harbors, and ports. Bay and river margins have a high potential for the occurrence and preservation of prehistoric sites. Prior channel dredging has disturbed buried and/inundated prehistoric archaeological sites in the coastal plain of the Gulf of Mexico. It is assumed that some of the sites or site information were unique or significant. In many areas, COE requires surveys prior to dredging activities to minimize such impacts.

Trawling activity would only affect the uppermost portion of the sediment column (Garrison et al., 1989). This zone would already be disturbed by natural factors, and site context to this depth would presumably be disturbed. Therefore, no effect of trawling on prehistoric sites is assumed. Investigations prior to construction can determine whether prehistoric archaeological resources occur at these sites.

Table 4-9 of the Multisale EIS indicates the projected coastal infrastructure related to OCS Program activities in the cumulative activity area. Investigations prior to construction can determine whether prehistoric archaeological resources occur at these sites.

Because BOEMRE does not have jurisdiction over pipelines in State waters, the archaeological resource protection requirements of the NHPA are not within BOEMRE's jurisdiction. However, other Federal agencies, such as COE, which lets permits associated with pipelines in State waters, are responsible for the protection of archaeological resources under the NHPA. Therefore, the impacts that might occur to archaeological resources by pipeline construction within State waters should be mitigated under the requirements of the NHPA.

Over 100 hurricanes have made landfalls along the northern Gulf of Mexico coast from the Florida Panhandle to Texas over the past century (Liu and Fearn, 2000; Keim and Muller, 2009). Prehistoric sites in shallow waters and on coastal beaches are exposed to the destructive effects of wave action and scouring currents. Under such conditions, it is highly likely that artifacts would be dispersed and the site context disturbed. Some of the original information contained in the site would be lost in this process. Overall, a significant loss of data from prehistoric sites has probably occurred, and will continue to occur, in the northeastern Gulf from the effects of tropical storms.

Summary and Conclusion

Several impact-producing factors may threaten prehistoric archaeological resources of the Gulf of Mexico. An impact could result from a contact between proposed oil and gas activities (including

pipeline construction, platform installation, drilling rig emplacement and operation, dredging, and anchoring activities) and an oil spill and subsequent cleanup efforts. Each of these activities or events could damage and destroy a prehistoric archaeological site located on the continental shelf. Archaeological surveys, where required, and the resulting archaeological analyses completed prior to an operator beginning oil and gas activities on a lease are expected to be highly effective at identifying possible prehistoric sites. The OCS development prior to the first required archaeological survey in 1973 has possibly impacted sites containing significant or unique prehistoric information, and it is possible that, even with current survey methods, prehistoric archaeological sites may be missed. No significant new information was found at this time that would alter the overall conclusion that cumulative impacts on prehistoric archaeological sites associated with the CPA proposed action is expected to be minimal. Because of continued regulations and surveys, the potential impact from the CPA proposed action to prehistoric archeological resources would be decreased.

4.1.1.21. Human Resources and Land Use

4.1.1.21.1. Land Use and Coastal Infrastructure

The BOEMRE has reexamined the analysis for land use and coastal infrastructure presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. While some new information was found, none of it conclusively changes the description of environmental effects. It is too early to determine substantial, long-term changes as a result of the DWH event and the subsequent drilling suspensions. The BOEMRE anticipates that there will be some long-term consequences and these will become apparent over time. Additionally, for the interim, BOEMRE recognizes the need to continue monitoring all resources for changes that are applicable for land use and infrastructure. Short-term impacts and potential long-term impacts related to the DWH event, in general, and the drilling suspensions, in particular, are discussed at the end of the chapters below on the "Description of the Affected Environment" (**Chapter 4.1.1.21.1.1**) and "Impacts of Accidental Events" (**Chapter 4.1.1.21.1.3**).

A detailed description of the affected environment and full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action and the proposed action's incremental contribution to the cumulative impacts are presented in the Multisale EIS. A summary of those analyses and their reexamination due to new information and the addition of the 181 South Area was presented in the 2009-2012 Supplemental EIS. The following is a summary of the information presented in the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The CPA proposed action would not require additional coastal infrastructure, with the possible exception of 0-1 new gas processing facility and 0-1 new pipeline landfall, and it would not alter the current land use of the analysis area. In fact, as industry responds to the new environment since the lifting of the drilling suspensions, increased scrutiny of industry practices post-DWH event, and pending regulatory revisions, the 0-1 projection range becomes even more conservative, i.e., it becomes even more likely that the number would be zero (Dismukes, personal communication, 2010a). Thus, the existing oil and gas infrastructure is expected to be sufficient to handle development associated with the proposed action. There may be some expansion at current facilities, but the land in the analysis area is sufficient to handle such development. There is also sufficient land to construct a new gas processing plant in the unlikely event that one should be needed. However, because the current spare capacity at existing facilities should be sufficient to satisfy new gas production, any such a need would likely materialize only toward the end of the 40-year life of the proposed action (Dismukes, personal communication, 2010b). This excess capacity substantially diminishes the likelihood of new facility construction. Existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs. Minor accidental events such as oil or chemical spills, blowouts, and vessel collisions would have no long-term negative effects on land use. Coastal or nearshore spills, as well as vessel collisions, could have short-term adverse effects on coastal infrastructure, requiring the cleanup of any oil or chemicals spilled. The incremental contribution of the proposed action to the cumulative impacts on land use and coastal infrastructure are expected to be minor. An analysis of impacts from a catastrophic event such as the DWH event can be found in **Appendix B**.

4.1.1.21.1.1. Description of the Affected Environment

For the proposed CPA action, the primary region of geographic influence is coastal Louisiana, Mississippi, and Alabama. Oil and gas activities are quite limited in the Florida area. Land use in the CPA analysis area has not substantially changed since the Multisale EIS (Chapter 3.3.5.1.2) or the 2009-2012 Supplemental EIS (Chapter 4.1.16.1.1) and that description is summarized below.

The coastal zone of the northern GOM is not a physically, culturally, or economically homogenous unit (Gramling, 1984a). The counties and parishes along the coasts of Louisiana, Mississippi, Alabama, and Florida represent some of the most valuable coastline in the U.S. Not only does it include miles of recreational beaches and the protection of an extended system of barrier islands, but it also has deepwater ports, oil and gas support industries, manufacturing, farming, ranching, and hundreds of thousands of acres of wetlands and protected habitat. These counties and parishes vary in their histories and in the composition and economic activities of their respective local governments.

According to the U.S. Department of Agriculture's Economic Research Service, which classifies counties into economic types that indicate primary land-use patterns, 3 of the 90 counties/parishes in the analysis area are classified as farming dependent, 6 as mining dependent (suggesting the importance of oil and gas development to these local economies), 18 as manufacturing dependent, 24 as government employment centers, and 20 as tied to service employment. The Economic Research Service also classifies counties in terms of their status as a retirement destination; 25 of the 90 counties/parishes are considered major retirement destinations (U.S. Dept. of Agriculture, Economic Research Service, 2004). The varied land-use patterns are displayed in Figure 3-16 of the Multisale EIS.

The BOEMRE defines the analysis area for potential impacts on population, labor, and employment as that portion of the GOM coastal zone whose social and economic well-being (population, labor, and employment) is directly or indirectly affected by the OCS oil and gas industry. In this description of the socioeconomic environment, sets of counties (and parishes in Louisiana) have been grouped on the basis of intercounty commuting patterns into LMA's, as identified by Tolbert and Sizer (1996). The methodology employed by Tolbert and Sizer is fully described in the Multisale EIS. Along the Gulf Coast, from the southern tip of Texas to Miami and the Florida Keys, 23 LMA's were identified and comprise the 13 BOEMRE-defined EIA's for the Gulf of Mexico region. The counties and parishes that form the LMA's and EIA's are listed in **Table 4-23**, and the EIA's are visually illustrated in **Figure 2-2**.

The LMA's geographically adjacent to the CPA include Lake Charles, Lafayette, Baton Rouge, Houma, and New Orleans, Louisiana; Biloxi-Gulfport, Mississippi; and Mobile, Alabama. The LMA's geographically adjacent to the EPA are all within Florida and include Pensacola, Panama City, Tallahassee, Lake City, Gainesville, Ocala, Tampa-St. Petersburg, Sarasota, Ft. Myers, and Miami. Use of the LMA geography brings together not only counties immediately adjacent to the GOM but also counties tied to coastal counties as parts of functional economic areas. An analysis that encompasses where people live as well as where they work permits a more meaningful assessment of the impact of offshore oil and gas activities. Because exploration, development, and production activities on the OCS draw on existing infrastructural, economic, and labor capacity from across the GOM region, the socioeconomic impacts of the proposed action in an individual planning area (WPA, CPA, and EPA) are not limited to geographically adjacent areas. For this reason, BOEMRE's impact analysis analyzes the potential impacts in all 13 EIA's regardless of where the proposed action is taking place.

The Louisiana coastal area includes broad expanses of marshes and swamps interspersed with ridges of higher well-drained land. Southeastern Louisiana is a thriving metropolitan area hosting shipping, navigation, U.S. Navy facilities, and oil and chemical refineries. Historically, Terrebonne, Plaquemines, and Lafourche Parishes have been the primary staging and support area for offshore oil and gas exploration and development.

Coastal Mississippi includes bays, deltas, marshland, and waterways. Two-thirds of the coast is devoted to State-chartered, beachfront gambling enterprises and heavy tourism. One-third is industrial, e.g., oil refining and shipbuilding, boat and helicopter facilities, and an onshore support base for drilling and production.

Coastal resource-dependent industries in Alabama include navigation, tourism, marine recreation, commercial fishing, and, since its 1979 discovery in State waters, natural gas development and production, along with minimal oil production. The military has long had a presence in the area.

An extensive maritime industry exists in the northern GOM. There is a substantial amount of domestic waterborne commerce in the analysis area and also some foreign maritime traffic. For the year 2005, seven of the leading 25 U.S. ports ranked by total trade tonnage are located in Louisiana, Mississippi, Alabama, and Florida (American Association of Port Authorities, 2007). Chapter 3.3.5.6 of the Multisale EIS includes a detailed description of the Gulf maritime industry in the analysis area.

Infrastructure that supports oil and gas exploration and development in the GOM region is far reaching and consists of several categories including platform fabrication yards, shipyards, shipbuilding manufacturers, service bases, port facilities, pipeline manufacturers, pipecoating yards, waste management facilities, transportation facilities, gas processing plants, natural gas storage facilities, LNG facilities, refineries, and petrochemical plants, to name a few.

The OCS-related offshore infrastructure includes offshore production systems, platform fabrication, pipelines, barges, service vessels, and helicopters. Chapter 3.3.5.7 of the Multisale EIS describes the various types of offshore infrastructure.

The OCS-related coastal infrastructure is large, supports OCS development, and consists of thousands of small and large contractors covering virtually every facet of OCS activity, including service bases, construction facilities for platform fabrication, pipecoating, pipelines, shipbuilding, and processing facilities such as gas processing plants, refineries and petrochemical plants, as well as terminal facilities such as pipeline shore facilities, barge terminals, and it also includes waste disposal facilities. Chapter 3.3.5.8 of the Multisale EIS details the various types of infrastructure mentioned above.

See Chapter 3.3.3 of the Multisale EIS for a listing of major public, recreational, and conservation areas; Chapter 3.3.5.6 of the Multisale EIS for a discussion of major ports and waterways; and Figures 3-13 through 3-15 of the Multisale EIS for a description of OCS infrastructure.

Deepwater Horizon Event

In response to the DWH event, the Department of the Interior Secretary Ken Salazar imposed temporary suspensions on certain offshore drilling. The moratorium was modified on May 27, 2010, to allow drilling only in shallow waters less than 500 ft (152 m) deep (USDOI, Office of Public Affairs, 2010a). However, only a limited amount of drilling has actually resumed because of new information requirements as clarified in (NTL 2010-N06), the time it takes for operators to comply, and the increasing rate at which BOEMRE is able to process permit applications (Weinstein, 2010). For example, from June 28, 2010, when new requirements were announced, until September 10, 2010, there were 13 Applications to Permit Drilling filed. Of the 13, five had been approved and eight were pending as of September 14, 2010 (USDOI, Office of Public Affairs, 2010b). On October 12, 2010, the remaining deepwater drilling suspension was lifted in its entirety. Operators are in the process of meeting the new requirements issued since the DWH event, and BOEMRE continues to review and approve permits and plans. The impacts of the suspensions and the temporary interruption in permitting are being experienced at Port Fourchon, where rental rates were cut by 30 percent as an incentive for businesses to stay. However, companies have removed a large portion of their equipment from the port and there has been a substantial decrease in helicopter flights and servicing of rigs. Many companies have had to trim their budgets by cutting hours and salaries. Support services companies, such as chemical suppliers, and welders have also been affected (Lohr, 2010). The effects of this decreased demand will ripple through the various infrastructure categories (e.g., fabrication yard, shipyards, port facilities, pipecoating facilities, gas processing facilities, waste management facilities, etc.) and also will affect the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, mud/drilling fluid/lubricant suppliers, etc.). The BOEMRE will continue to monitor these infrastructure effects as they evolve over time.

Land use experienced a more immediate but short-term impact, with temporary waste staging areas and decontamination areas that were set up to handle the spill-related waste. Concerns about waste management practices were expressed by the government and public (Barringer, 2010). The USEPA, in consultation with the Coast Guard, issued solid waste management directives to address the issue of contaminated materials and solid or liquid wastes that were recovered as a result to cleanup operations (USEPA, 2010k and 2010l). Twenty-five waste staging areas were set up across Louisiana, Mississippi, Alabama, and Florida. Six decontamination areas were stationed in Mississippi, Alabama, and Florida. The USEPA visited each staging and decontamination area once per week and each landfill two times per month, and they documented their findings on the USEPA public website. There were some issues, but

nothing that would appear to cause a long-term impact (USEPA, 2010m). Additional description of the DWH event's waste stream is found in **Chapter 4.1.1.21.4**.

It should be noted that the post-DWH environment in which we find ourselves is dynamic and ever-changing. The BOEMRE will continue to monitor these resources over time as long-term impacts to the affected environment become more evident.

4.1.1.21.1.2. Impacts of Routine Events

Background/Introduction

A detailed impact analysis of routine events on land use and coastal infrastructure for the CPA proposed action can be found in Chapter 4.2.1.1.13.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.16.1.2 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Impact-producing factors associated with the CPA proposed action that could affect land use and coastal infrastructure include (1) gas processing facilities, (2) pipeline landfalls, (3) service bases, (4) navigation channels, and (5) waste disposal facilities.

Chapter 4.1.2.1 of the Multisale EIS and Chapter 3.1.2 of the 2009-2012 Supplemental EIS discuss OCS-related coastal infrastructure and projected new coastal infrastructure that may result from the CPA proposed action or the OCS Program, including the potential need for the construction of new facilities and/or the expansion of existing facilities. Based on current information, the development scenario presented in the 2009-2012 Supplemental EIS has been reconsidered and revised for the CPA proposed action, but changes have been few. All onshore infrastructure requires permits for construction and operation. The BOEMRE is not the permitting agency for these activities. The permitting agencies for any onshore infrastructure would be the State in which the activity would occur, and/or COE, and/or USEPA. According to the scenario analysis in the 2009-2012 Supplemental EIS, the construction of 0-1 new gas processing facilities would be expected to occur near the end of the 40-year life of the proposed action. Most of the projected new pipeline would be offshore and would tie into the existing offshore pipeline infrastructure. According to the scenario analysis, 0-1 new pipeline landfalls would be expected to occur toward the end of the 40-year lifespan of the proposed lease sale. According to these BOEMRE projections, no other new coastal infrastructure would be expected to result from the proposed action. Given the uncertain environment of the post-DWH event, the application of the scenario revised for the CPA proposed action is very conservative since the likelihood is diminished that any new gas processing facility or pipeline landfall would result from the proposed action. That is, the lingering effects of the drilling suspensions, changes in Federal requirements for drilling safety, and the temporary interruption in the permit approval process has depressed existing demand for gas processing facilities and pipeline landfalls; hence, the likelihood of new gas processing facilities or pipeline landfalls has moved closer to zero and farther from one (Dismukes, personal communication, 2010a). However, BOEMRE recognizes the need to continue monitoring all resources for changes that are applicable for land use and infrastructure. Maintenance dredging of existing navigation channels is still expected, but no new navigation channels are expected to be dredged as a result of the CPA proposed action. The volume of OCS-generated waste is closely correlated with the level of offshore drilling and production activity. Demand for waste disposal facilities is influenced by the volume of waste generated. At this time, it is unclear how long the current slowdown in activity will continue or how it might affect later years. Until OCS drilling activity recovers, potential for a new waste facility as a result of the CPA proposed action is highly unlikely.

Chapter 4.1.2.1.4.2 of the Multisale EIS and Chapter 3.1.2.2 of the 2009-2012 Supplemental EIS discuss gas processing plants and the potential for new facilities and/or expansion at existing facilities. Over the past 5 years, there has been a substantial decrease in offshore natural gas production, partially as a result of increasing emphasis on onshore shale gas development, which is less expensive to produce and provides larger per well production opportunities and reserve growth. Also, there has been a trend toward

more efficient gas processing facilities with greater processing capacities. In Alabama, Mississippi, and the eastern portion of South Louisiana, plant capacity increased significantly as plant expansions occurred and new larger plants were built in response to offshore production (USDOE, Energy Information Administration, 2006). While natural gas production on the OCS shelf (shallow water) has been rapidly declining, deepwater gas production has been increasing, but not quickly enough to make up the difference. Increasing onshore shale gas development, declining offshore gas production, and the increasing efficiency and capacity of existing gas processing facilities are trends that have combined to lower the need for new gas processing facilities along the Gulf Coast in the past 5 years. Combined with this, existing facilities that were already operating at about 50 percent of capacity prior to the 2005 hurricane season are operating at even lower capacity utilization levels now. Spare capacity at existing facilities should be sufficient to satisfy new gas production for many years, although there remains a slim chance that a new gas processing facility may be needed by the end of the 40-year life of the proposed action (Dismukes, personal communication, 2010b).

The BOEMRE analyzes the potential for new pipeline landfalls to determine the potential impacts to wetlands and other coastal habitats. In Chapter 4.1.2.1.7 of the Multisale EIS and other previous EIS's and EA's, BOEMRE assumed that the majority of new Federal OCS pipelines would connect to the existing infrastructure in Federal and State waters and that very few would result in new pipeline landfalls. Therefore, BOEMRE projected up to one pipeline landfall per lease sale. Between the Multisale EIS and the 2009-2012 Supplemental EIS, BOEMRE tested this assumption by analyzing past lease sale outcomes (USDOI, MMS, 2007d). This analysis shows that it is generally unlikely that even one landfall would result from an individual lease sale. A mature pipeline network already exists in the Gulf of Mexico and companies have very strong financial incentives to reduce their costs by designing and utilizing pipeline systems to their fullest extent possible. Companies consider "economies of scale" in pipeline transportation, maximizing the amount of product moved through a constructed pipeline to decrease the long-run, average cost of production. Mitigation costs for any new wetland and environmental impacts, as well as various landowner issues at the landfall point are additional considerations. These are strong incentives to move new production into existing systems and to avoid creating new landfalls (USDOI, MMS, 2007d). This analysis confirms BOEMRE's assumption that the majority of new pipelines constructed would connect to the existing infrastructure in Federal and State waters and that very few would result in new pipeline landfalls. However, there may be instances where new pipelines would need to be constructed. Location would be a determining factor; if there are no existing pipelines reasonably close and it is more cost effective to construct a pipeline to shore, then there may be a new OCS pipeline landfall. However, the very strong financial incentives to link into the existing, mature pipeline network make this highly unlikely (Dismukes, personal communication, 2010c). **Chapters 4.1.1.3.2 and 4.1.1.4.2** provide a detailed discussion of coastal barrier beaches and wetlands, respectively, and potential pipeline landfall impacts to those resources.

Chapters 3.3.5.8.1 and 4.1.2.1.1 of the Multisale EIS and Chapter 3.1.2.1 of the 2009-2012 Supplemental EIS present a description of OCS-related service bases. A service base is a community of businesses that load, store, and supply equipment, supplies, and personnel that are needed at offshore work sites. The proposed action is not projected to change existing OCS-related service bases or require construction of new service bases. Instead, it would contribute to the use of existing service bases. **Figure 3-4** shows the 50 service bases the industry currently uses to service the OCS. These facilities are identified as the primary service bases from plans received by BOEMRE. The ports of Fourchon, Cameron, Venice, and Morgan City, Louisiana, are the primary service bases for Gulf of Mexico mobile rigs. Major platform service bases in the CPA are Cameron, Fourchon, Intracoastal City, Morgan City, and Venice, Louisiana; Pascagoula, Mississippi; and Theodore, Alabama.

Service bases are utilized for three types of OCS offshore support: supply vessel, crewboat, and helicopter. Supply vessels transport pipe and bulk supplies, and the supply vessel base serves as the loading point and provides temporary storage. Crewboats transport personnel and small supplies. Collectively, supply vessels and crewboats are known as "OSV's" (offshore supply vessels). There are approximately 1,200 OSV's operating in the GOM. Important drivers for the OSV market include the level of offshore exploration and drilling activities, current oil and gas prices, expectations for future oil and gas prices, and customer assessments of offshore prospects (Dismukes, in preparation-b). High demand for OSV's translates into a positive impact on OCS-related employment (see **Chapter 4.1.1.21.3**, "Economic Factors" below). Helicopters transport small supplies and workers and also may patrol

pipelines to spot signs of damage or leakage. Helicopters service drilling rigs, production platforms, and pipeline terminals, as well as specialized vessels, such as jack-up barges. The OCS activity levels and offshore oil and gas industry transportation needs substantially influence the demand for and profitability of helicopter services (Dismukes, in preparation-b). Exploration and development plans filed with BOEMRE identify the expected number and frequency of vessel and helicopter trips, and the primary and secondary service bases for each project. In the event of changes in weather or operation conditions, a small amount of vessel and helicopter traffic may be dispatched from other bases. However, these deviations would occur on a temporary basis, and vessel traffic and helicopter transport should return to the primary and secondary bases as timely as possible.

Chapter 4.1.2.1.9 of the Multisale EIS and Chapter 3.1.2.1 of the 2009-2012 Supplemental EIS discuss navigation channels along the Gulf Coast. Much of the traffic navigating these channels is unrelated to OCS activity, and the current system of navigation channels in the northern GOM is projected to be adequate for accommodating traffic generated by the CPA proposed action. The Gulf-to-port channels and the Gulf Intracoastal Waterway that support prospective OCS ports are generally deep and wide enough to handle OCS-related traffic and are maintained by regular dredging (**Figure 3-5**). The COE is the responsible Federal agency for the regulation and oversight of navigable waterways. The maintained depths for these waterways are shown in Table 3-36 of the Multisale EIS. All lease sales contribute to the demand for OSV support; hence, it also contributes to the vessel traffic that moves in and out of support facilities. Therefore, the CPA proposed action is likely to contribute to the continued need for maintenance dredging of existing navigation channels. However, no new navigation channels are expected to be dredged as a result of the proposed action. Maintenance dredging is essential for proper water depths in channels to allow all shipping to move safely through the waterways to ports, services bases, and terminal facilities. Several million cubic yards of sand, gravel, and silt are dredged from waterways and harbors every year. This is a controversial process because it necessarily occurs in or near environmentally sensitive areas such as valuable wetlands, estuaries, and fisheries (Dismukes, in preparation-b). **Chapter 4.1.1.4.2** provides a discussion of wetlands and the impacts of navigation channel dredging.

Chapters 4.1.2.2 of the Multisale EIS and Chapter 4.1.16.1.2 of the 2009-2012 Supplemental EIS discuss OCS waste disposal. These analyses and other previous EIS's and EA's concluded that no new solid-waste facilities would be built as a result of a single lease sale or as a result of the OCS Program. Recent research further supports these past conclusions that existing solid-waste disposal infrastructure is adequate to support both existing and projected offshore oil and gas drilling and production needs (Dismukes et al., 2007). The industry trend is toward innovative methods to handle wastes to reduce the potential for environmental impacts; e.g., hydrocarbon recovery/recycling programs, slurry fracture injection, treating wastes for reuse as road base or levee fill, and segregating waste streams to reduce treatment time and improve oil recovery. The volume of OCS waste generated is closely correlated with the level of offshore drilling and production activity (Dismukes, in preparation-a). Before the DWH event, BOEMRE analyses indicated that there was an abundance of solid waste capacity in the GOM region and thus highly unlikely that any new waste facilities would be constructed. If any increase in the need for capacity develops, it would probably be met by expansion of existing facilities. However, now it is unclear whether this will remain true and more research is needed (Dismukes, personal communication, 2010d). In recent months, due to the drilling suspensions and temporary interruption in permit approval slowdown, there has been some reduction in offshore drilling activity. Given this situation, demand for waste disposal facilities may not be likely to increase. However, at this time BOEMRE cannot predict how long these impacts continue or how long it will take for activity levels to recover. The BOEMRE will continue to monitor waste-disposal demands and activity in the post-DWH event environment. **Chapter 4.1.1.21.4.2** provides a discussion of environmental justice issues related to waste disposal facilities.

Summary and Conclusion

The impacts of routine events associated with the CPA proposed action are uncertain due to the post-DWH event environment, lingering effects of the drilling suspensions, changes in Federal requirements for drilling safety, and the temporary interruption of the permit approval process. The BOEMRE projects 0-1 new gas processing facilities and 0-1 new pipeline landfalls for the proposed action. However, based

on the most current information available, there is a very slim chance that either would result from the CPA proposed action, and if a new gas processing facility or pipeline landfall were to result, it would likely occur toward the end of the 40-year analysis period. The likelihood of a new gas processing facility or pipeline landfall is much closer to zero than to one (Dismukes, personal communication, 2010a). The BOEMRE anticipates that there would be maintenance dredging of navigation channels and an increase in activity at services bases as a result of the CPA proposed action. If drilling activity recovers post-DWH event and increases, there could be new increased demand for a waste disposal services as a result of the CPA proposed action. Because of the current near zero estimates for pipeline landfalls and processing facility construction, the routine activities associated with the CPA proposed action would have little effect on land use.

As a result of the DWH event, it is too early to determine substantial, long-term changes in routine event impacts to land use and infrastructure. The BOEMRE anticipates these changes would become apparent over time. Therefore, BOEMRE recognizes the need to continue monitoring all resources for changes that are applicable for land use and infrastructure. From the information that is currently available, in regard to land use and infrastructure, it does not appear that there would be adverse impacts from routine events associated with the CPA proposed action.

4.1.1.21.1.3. Impacts of Accidental Events

Background/Introduction

Impacts of accidental events on land use and coastal infrastructure for the CPA proposed action are discussed in Chapter 4.4.14.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes new information since publication of the Multisale EIS is presented in Chapter 4.1.16.1.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS, the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Proposed Action Analysis

Impact-producing factors associated with the CPA proposed action that could affect land use and coastal infrastructure include (1) oil spills, (2) vessel collisions, and (3) chemical/drilling-fluid spills. The DWH event was an accidental event of historic and catastrophic proportion, the largest blowout in U.S. history, and the first to occur on the OCS in over 30 years. Such events should be distinguished from accidental events that are smaller in scale and that occur more frequently. Chapter 4.3.1.3 of the Multisale EIS provides a detailed discussion of oil spills that have occurred and their frequency. Detailed analysis of a high-impact, low-probability catastrophic event such as DWH event is provided in **Appendix B**.

Oil spills may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Detailed risk analysis of offshore oil spills ≥1,000 bbl and coastal spills associated with the CPA proposed action is provided in Chapters 4.3.1.5, 4.3.1.6, and 4.3.1.7 of the Multisale EIS, respectively. Because oil spilled in the offshore areas normally volatilizes and is dispersed by currents, it has a low probability of contacting coastal areas. Oil spills in coastal and inland waters, such as spills resulting from the operations of offshore supply vessels, pipelines, barges, tanker ships, and ports are more likely to affect BOEMRE-recognized coastal infrastructure categories. **Table 3-7** contains the estimated number of oil spills that could happen in Gulf coastal waters as a result of an accidental event associated with the CPA proposed action.

Vessel collisions may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Chapter 4.3.3 of the Multisale EIS provides a detailed discussion of vessel collisions. The BOEMRE data show that, from 1996 through 2005, there were 129 OCS-related collisions. The majority of vessel collisions involve service vessels colliding with platforms or pipeline risers, although sometimes vessels collide with each other. These collisions often result in spills of various substances and, while most occur on the OCS far from shore, ones in coastal waters can have consequences to land use and coastal infrastructure. For example, on July 23, 2008, a barge carrying heavy fuel collided with a tanker ship in the Mississippi River at New Orleans, Louisiana. Over several days the barge leaked approximately 419,000 thousands of gallons of fuel. From New Orleans to the

south, 85 mi (137 km) of the river were closed to all traffic while cleanup efforts were undertaken, causing a substantial backup of river traffic (USDOC, NOAA, 2008c).

Chemical/drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Chapter 4.3.4 of the Multisale EIS provides a detailed discussion of chemical and drilling-fluid spills. Each year, between 5 and 15 chemical spills are expected to occur; most of these are ≤50 bbl in size. Large spills are much less frequent. For example, from 1964 to 2005, only two chemical spills of ≥1,000 bbl occurred. Even though additional production chemicals are needed in deepwater operations where hydrate formation is a possibility, spill volumes are expected to remain stable because of advances in subsea processing.

With the exception of a catastrophic accidental event, such as the DWH event, the impact of oil spills, vessel collisions, and chemical spills are not likely to last long enough to adversely affect overall land use or coastal infrastructure in the analysis area.

Deepwater Horizon Event

While it is too early to determine the final outcome and impacts of the DWH event, much is known. In the months following the DWH event, there have been some short-term, indirect impacts on land use and coastal infrastructure caused by the drilling suspension imposed on July 12, 2010, and lifted on October 12, 2010; by its lingering effects; and from changes in Federal requirements for drilling safety and the permit approval process. Drilling has actually resumed in shallow waters but must meet new drilling application information requirements as clarified in NTL 2010-N06. Deepwater drilling has commenced and is dependent upon operators fulfilling new more stringent requirements and BOEMRE permit approvals. The impacts of the suspension were experienced at Port Fourchon, Louisiana, where rental rates were cut by 30 percent as an incentive for businesses to stay. However, companies have removed a large portion of their equipment from the port and there has been a substantial decrease in helicopter flights and servicing of rigs.

The deepwater exploration activity at Port Fourchon is expected to resume with the approval of deepwater permits. The rate of drilling is dependent upon compliance with more stringent Federal enforcement, the industry's efforts to fulfill new safety requirements that are not yet finalized, and the resulting slow pace for drilling application approvals. Deepwater exploratory drilling is a huge economic driver for jobs, investments, vessels, etc. (Chaisson, personal communication, 2010). In the long term, the effects of the suspension and its aftermath are not expected to change the basic market fundamentals that drive demand for support infrastructure. In the short term, the decrease in deepwater exploratory drilling is expected to ripple through the various infrastructure categories (e.g., fabrication yard, shipyards, port facilities, pipecoating facilities, gas processing facilities, waste management facilities, etc.) and will also affect the oil and gas support sector businesses (e.g., drilling contractors, offshore support vessels, helicopter hubs, mud/drilling fluid/lubricant suppliers, etc.). See **Chapter 4.1.1.21.3** for a detailed analysis of economic factors. The BOEMRE will continue to monitor these infrastructure effects as they evolve over time.

Land use experienced more immediate, short-term impacts from the establishment of temporary waste staging areas and decontamination areas set up to handle spill-related waste. Concerns about waste management practices were expressed by government and the public (Barringer, 2010). The USEPA, in consultation with the Coast Guard, issued solid waste management directives to address the issue of contaminated materials, and solid or liquid wastes that were recovered as a result to cleanup operations (USEPA, 2010k and 2010l). Fifteen waste staging areas spread out across Louisiana, and there were none in Texas. No decontamination areas were set up in either Louisiana or Texas. The USEPA visited each staging and decontamination area once per week and each landfill two times per month, and they documented their findings on the USEPA public website. There were some issues, but nothing that would appear to cause a long-term impact (USEPA, 2010m). Additional description of the DWH event's waste stream is located in **Chapter 4.1.1.21.4**. Detailed analysis of a high-impact, low-probability catastrophic event such as the DWH event may be found in **Appendix B**.

Summary and Conclusion

Many of the impacts of the DWH event to land use and infrastructure have been temporary and short-term, such as the ship decontamination sites and the waste staging areas established in the immediate

aftermath of the DWH event (USDOT, 2010). The indirect effects on infrastructure use are still rippling through the industry, but this should resolve as issues with the suspensions, permitting, etc. are resolved. With regards to land use and infrastructure, the post-DWH event environment remains somewhat dynamic, and BOEMRE will continue to monitor these resources over time and to document short- and long-term DWH event impacts. In the future, the long-term impacts of the DWH event will be clearer as time allows the production of peer-reviewed research and targeted studies that determine those impacts. The DWH event was a low-probability, high-impact catastrophic event. For the reasons set forth in the analysis above, the kinds of accidental events that are likely to result from the CPA proposed action are not likely to significantly affect land use and coastal infrastructure. This is because accidental events offshore would have a small probability of impacting onshore resources. Also, if an accident occurs nearshore, it would be most probably be near a facility; therefore, the impacts would be temporary and localized because of the decrease in response time.

4.1.1.21.1.4. Cumulative Impacts

Background/Introduction

A detailed analysis of cumulative impacts upon land use and coastal infrastructure for the CPA proposed action can be found in Chapter 4.5.15.1 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.16.1.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The cumulative analysis considers the effects of impact-producing factors from OCS and State oil and gas activities. The OCS- and State-related factors consist of prior, current, and future OCS and State lease sales. Chapters 3.3.5.1.2 and 3.3.5.8 of the Multisale EIS discuss land use and OCS-related oil and gas infrastructure associated with the analysis area. The vast majority of this infrastructure also supports oil and gas production in State waters as well as in coastal areas onshore.

According to BOEMRE development scenario analysis, the construction of 0-1 new gas processing facilities would be expected to occur near the end of the 40-year life of the proposed action. Most new pipelines would be offshore and would tie into the existing offshore pipeline infrastructure. According to the scenario analysis, 0-1 new pipeline landfalls would be expected to occur toward the end of the 40-year lifespan of the proposed lease sale. Those projections also called for no new waste disposal facilities due to existing excess capacity along the Gulf Coast. Recently, based on the analysis of historical data, BOEMRE validated its past scenario projections of new gas processing facilities and new pipeline landfalls and found its projections to be conservative; that is, the actual numbers proved to be equal to, or less than, the projected numbers. Current scenario projects are also likely to be conservative (Dismukes, personal communication, 2010a).

In the months following the DWH event, much information has been generated regarding the consequences of the oil spill and subsequent drilling suspensions. Because petroleum activities on the OCS and in State waters and coastal areas are driven by market fundamentals, the DWH event and related events are not expected to have long-term consequences on them. Hence, these events are not expected to affect land use and infrastructure in the cumulative case. However, because the post-DWH event environment is dynamic and ever-changing, BOEMRE is currently conducting ongoing monitoring of post-DWH event impacts to land use and coastal infrastructure, and BOEMRE will conduct targeted and peer-reviewed research should this monitoring identify long-term impacts of concern.

Land use in the analysis area will evolve over time. The majority of change is likely to occur from general, regional economic and demographic growth rather than from activities associated with current OCS and/or State offshore petroleum production or future planned OCS or State lease sales. Projected new coastal infrastructure as a result of the OCS Program is shown by State in Table 4-9 of the Multisale EIS. The BOEMRE development scenarios consider demand from both current and future OCS and State leases. These scenarios project 0-1 new gas processing facilities to result from the proposed action. However, this number is derived from the estimated demand for future processing capacity. Given current industry practice, it is likely that few (if any) new, Greenfield gas processing facilities would actually be constructed along the CPA. Instead, it is likely that a large share (and possibly all) of any additional natural gas processing capacity that is needed in the industry will be developed at existing

facilities, through future investments in expansions, and/or replacement of depreciated capital equipment. Also, these BOEMRE scenario projections are conservative; i.e., they likely overestimate the additional capacity that would be required.

Over the past 5 years, there has been a substantial decrease in offshore natural gas production, partially as a result of increasing emphasis on onshore shale gas development, which is less expensive to produce and provides larger per-well production opportunities and reserve growth. Also, there has been a trend toward more efficient gas processing facilities with greater processing capacities (Dismukes, in preparation-a). In Alabama, Mississippi, and the eastern portion of South Louisiana, plant capacity increased significantly as plant expansions occurred and new larger plants were built in response to offshore production (USDOE, Energy Information Administration, 2006). While natural gas production on the OCS shelf (shallow water) has been rapidly declining, deepwater gas production has been increasing, but not quickly enough to make up the difference. Increasing onshore shale gas development, declining offshore gas production, and the increasing efficiency and capacity of existing gas processing facilities are trends that have combined to lower the need for new gas processing facilities along the Gulf Coast in the past 5 years. Combined with this, existing facilities that were already operating at about 50 percent of capacity prior to the 2005 hurricane season are operating at even lower capacity utilization levels now. Spare capacity at existing facilities should be sufficient to satisfy new gas production for many years, although there remains a slim chance that a new gas processing facility may be needed by the end of the 40-year life of the proposed action (Dismukes, personal communication, 2010b). Any additions to, or expansions of, current facilities would also support State oil and gas production and, should any occur, the land in the analysis area is sufficient to handle development. Thus, the results of OCS and State oil and gas activities are expected to minimally alter the current land use of the area.

Service base infrastructure supports offshore petroleum-related activities in both OCS and State waters. Any changes to offshore support infrastructure that occurs in the cumulative case are expected to be contained on available land. Service bases are industrial ports and are located in designated industrial parks designed with the intent to accommodate future oil and gas needs. Also, most of these are located in BOEMRE analysis areas that have strong industrial bases. Shore-based OCS and State servicing is expected to increase in the ports of Galveston, Texas; Port Fourchon, Louisiana; and Mobile, Alabama. There is sufficient land designated in commercial and industrial parks and adjacent to the Galveston and Mobile port areas. This would minimize disruption possible from port expansions to current residential and business use patterns. In contrast, while Port Fourchon has land designated for future expansion, the port has a limited amount of waterfront land available and, because of surrounding wetlands, may face capacity constraints in the long term. At present, there is a small amount of waterfront property available that is situated around Slip C (The Greater Lafourche Port Commission, 2010a) and approximately 55 ac (22 ha) of nonwaterfront property also available for lease (The Greater Lafourche Port Commission, 2010b). The port's 4,000-ac (1,620-ha) Northern Expansion is nearly complete and will essentially double its operational area. Phase 1 of the Northern Expansion is a 700-ac (284-ha) site containing 520 ac (210 ha), with 21,000 ft (6,400 m) of water frontage. Construction of 700 ft (213 m) of bulkhead in Slip B is complete and an additional 1,100 ft (335 m) of bulkhead is currently under construction. Another 1,425 ft (434 m) of bulkhead is scheduled for construction in 2010. Phase 1 of the Northern Expansion is nearly complete, and over 80 percent of total Phase 1 property is already leased (The Greater Lafourche Port Commission, 2010c). Port Fourchon serves as the primary support base for over 90 percent of existing deepwater projects. From 2008 through 2009, the demand for support base facilities continued to increase despite an economic recession. Prior to the DWH event, new facilities at the port were leased as soon as they could be constructed (Redden, 2009). Since the DWH event and the May 2010 drilling moratorium, port tenants have been struggling with the drop in exploration drilling even 8 weeks after the July drilling suspension was lifted on October 12, 2010. This hiatus is due to more stringent Federal enforcement, industry's efforts to fulfill new safety requirements, and the resulting slow pace for drilling application approvals. During this time, cleanup and decontamination work are keeping companies busy, but it is slated to cease at the end of December 2010. There is much uncertainty about what is going to happen at Port Fourchon from an economic standpoint when the decontamination work ends, and deepwater exploratory drilling is a huge economic driver for jobs, investments, vessels, etc. (Chaisson, personal communication, 2010). However, BOEMRE expects that this uncertainty to be short term and, because the economic prospectivity of the Gulf has not changed, deepwater activity at the port

will gradually increase to pre-DWH event levels after new Federal regulations are finalized and appropriate permit applications for new deepwater exploratory drilling are submitted and approved.

LA Hwy 1 is the only highway connecting Port Fourchon with the rest of Louisiana. This two-lane highway is surrounded by marshland and has been prone to extreme flooding over the years, jeopardizing critical access to Port Fourchon, which is the service base for 90 percent of OCS deepwater activity. While, in the absence of planned expansions, LA Hwy 1 would not be able to handle future OCS and State activities, a multiphase LA Hwy 1 improvement project is currently underway. On July 8, 2009, the new LA Hwy 1 fixed-span toll bridge over Bayou Lafourche connecting Port Fourchon and Leeville, Louisiana, was opened and marks partial completion of the first phase of improvements to LA Hwy 1 (*Toll Roads News*, 2009). A large portion of the tolls collected would be paid by transportation activities associated with OCS oil- and gas-related activities. The remaining portion of Phase 1 construction, a two-lane elevated highway from the bridge to Port Fourchon, is scheduled for completion in late 2011. There are continuing efforts to get Federal funding to construct Phase 2 of the project—an elevated highway from the Golden Meadow floodgates to Leeville, Louisiana (LA 1 Coalition, 2010a).

The South Lafourche Leonard Miller Jr. Airport recently opened a partial parallel taxiway and the Port commission has plans to extend it to full length. In the past 8 years, $20 million have been invested in the airport for improvements that include the paving of airport roadways, runway expansion and overlay, installation of fuel tanks, and construction of an extra large hanger. The runway expansion and overlay have increased the maximum aircraft weight to allow access by 20-passenger jets. From 2008 to 2009, activity at the airport increased 19 percent. Airport authorities are also in the second phase of implementing an Instrument Landing System like those found at major commercial airports as a navigational aid to pilots. The Greater Lafourche Port Commission recently acquired 1,200 ac (485 ha) of property near the airport and intends to develop that land into an industrial park (The Greater Lafourche Port Commission, 2010d).

If the service base expansion occurs in the cumulative case at the ports of Galveston, Texas, and Mobile, Alabama, this expansion would occur in areas that are already industrialized and would have little effect on land use and infrastructure. This is also true for Port Fourchon, Louisiana, although, in the cumulative case, expansion of this service base may eventually be constrained by surrounding wetlands. Limited highway access and airport capacity could also constrain service base expansion at Port Fourchon in the cumulative case. However, ongoing and planned improvement projects make this unlikely.

Summary and Conclusion

Activities relating to the OCS Program and State oil and gas production are expected to minimally affect the current land use of the analysis area because most subareas have strong industrial bases and designated industrial parks to accommodate future growth in oil and gas businesses. The BOEMRE projects 0-1 new gas processing facilities and 0-1 new pipeline landfalls for the proposed action, although this is a conservative estimate and the number is much closer to zero than to one. If a new gas processing facility or pipeline landfall were to occur, it would likely be toward the end of the 40-year analysis period (Dismukes, personal communication 2010b). There may be new increase demand for a waste disposal services as a result of the proposed action. Any service base expansion in the cumulative case would be limited, would occur on lands designated for such purposes, and would have minimal effects on land use and infrastructure. However, in the cumulative case it is possible that Port Fourchon expansions may eventually be constrained by surrounding wetlands. Based on the available information and current BOEMRE scenario projections, the cumulative impacts on land use and coastal infrastructure are expected to be minor, and the incremental contribution of the CPA proposed action to the cumulative impacts on land use and coastal infrastructure are also expected to be minor. The current post-DWH event environment is dynamic and BOEMRE will continue to monitor any developments regarding coastal land use and infrastructure.

4.1.1.21.2. Demographics

In light of the recent DWH event, BOEMRE has reexamined the analysis of demographics presented in the Multisale EIS and the 2009-2012 Supplemental EIS. While some new information was found related to the baseline conditions (most notably the new Woods & Poole Economics, Inc. (2010) population projection data), the incremental population impacts of the CPA proposed action, and the

impacts of accidental events, a reanalysis found that none of the new information altered the impact conclusions for demographics presented in the Multisale EIS and the 2009-2012 Supplemental EIS. While it is too early to determine if there will be any significant long-term demographic changes as a result of the DWH event and the subsequent drilling suspensions and given current information on the limited employment impacts to date (**Chapters 4.1.1.17, 4.1.1.18, 4.1.1.19, and 4.1.1.21.3**), BOEMRE anticipates that there will not be any substantial long-term population and demographic changes. However, BOEMRE will continue to monitor data and information as it becomes available. If there are substantial long-term employment impacts to the tourism and recreation, fishing, or energy industries in the area, there may be some out-migration from some affected areas in the region. Short-term impacts and potential long-term impacts related to the DWH event in general, and the drilling suspensions in particular, are discussed at the end of the sections below on the "Description of the Affected Environment" (**Chapter 4.1.1.21.2.1**) and "Impacts of Accidental Events" (**Chapter 4.1.1.21.2.3**).

A detailed description of the affected environment and full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action are presented in the Multisale EIS and the 2009-2012 Supplemental EIS, as are the proposed action's incremental contribution to the cumulative impacts. A summary of those analyses and their reexamination due to new information and the DWH event and drilling suspensions are presented in the following sections.

A brief summary of potential impacts follows. The CPA proposed action is projected to minimally affect the demography of the analysis area. Population impacts from the CPA proposed action are projected to be minimal (<1% of the total population) for any EIA in the Gulf of Mexico region. The baseline population patterns and distributions projected and described in **Chapter 4.1.1.21.2.1** below are expected to remain unchanged as a result of the CPA proposed action. The increase in employment discussed in **Chapter 4.1.1.21.3.2** is expected to be met primarily with the existing population and available labor force, with the exception of limited in-migration (some possibly foreign) projected for focal areas such as Port Fourchon. Accidental events associated with the proposed action, such as oil or chemical spills, blowouts, and vessel collisions, would likely have no effects on the demographic characteristics of the Gulf Coastal communities. The cumulative activities are projected to minimally affect the analysis area's demography.

4.1.1.21.2.1. Description of the Affected Environment

The description of the environment for demographics is described in Chapter 3.3.5.4 of the Multisale EIS and in Chapter 4.1.16.2.1 of the 2009-2012 Supplemental EIS. The following is a summary and update of the information presented in those documents. A search was conducted for new information since completion of the 2009-2012 Supplemental EIS that would impact the baseline demographics of the region. The BOEMRE examines demographic impacts over the 40-year life of the proposed action. The new 2011 CEDDS data from Woods & Poole Economics, Inc. (2010) was most relevant to this examination, and BOEMRE updated all baseline projections using these data. The limited supplemental information related to the short-term impacts of the DWH event and the drilling suspensions that is available is presented at the end of this section. However, this supplemental information does not change the Woods & Poole Economics, Inc.'s baseline population projections used to analyze impacts of the CPA proposed action and the OCS Program, which, as explained in **Chapter 4.1.1.21.2.4**, is used for the cumulative impact analysis. The methodology BOEMRE uses to measure employment impacts (and the subsequent demographic impacts that are generated by employment changes) over the 40-year life of the proposed lease sale recognizes that most of the employment that results from industry activities that result from the lease sale is not generated until 4-7 years after the sale. In contrast, the supplemental information provided below is related to current socioeconomic conditions.

Offshore waters of the WPA, CPA, and EPA lie adjacent to coastal Texas, Louisiana, Mississippi, Alabama, and Florida. The BOEMRE groups sets of counties and, in Louisiana, parishes into LMA's on the basis of intercounty commuting patterns. Twenty-three of these LMA's span the Gulf Coast and comprise the 13 BOEMRE-defined EIA's. **Table 4-23** lists the counties and parishes that comprise the LMA's and EIA's, and **Figure 2-2** illustrates the counties and parishes that comprise the EIA's; see Chapter 3.3.5.4.1 of the Multisale EIS for further detail. The nature of the offshore oil and gas industry is such that the same onshore impact area is used to examine activities in the WPA and CPA. First, workers commute long distances for rotations offshore that last for 2-3 weeks at a time, and there is great

flexibility between where employees live and where they work offshore in the GOM. Second, industry equipment and supplies for offshore projects in both planning areas come from throughout the region. Although the same overall onshore impact area is used to analyze sales in both planning areas, the impacts to the different individual EIA's do vary between WPA sales and CPA sales.

Tables 3-18 through 3-30 of the Multisale EIS provide projections of detailed demographic data for the EIA's using 2006 CEDDS data (Woods & Poole Economics, Inc., 2006). **Tables 4-24** through **4-36** of this Supplemental EIS provide updated projections of the data using the 2011 CEDDS data (Woods & Poole Economics, Inc., 2010). The EIA's total population increased by 6 percent between 2005 and 2010, to approximately 24.5 million. In the U.S., population age structures typically reflect the presence of the baby-boom generation. In the EIA's, the largest increases from 2005 to 2010 were in the Age 50 to 64 and Age 65 and Over categories, which grew by 16 percent and 10 percent, respectively. In the EIA's, the Hispanic population increased 17.2 percent between 2005 and 2010. This group is the second largest race/ethnic group in the area, making up 27.8 percent of the area's population in 2010. The total African-American population increased 5.2 percent between 2005 and 2010. Although Asians and Pacific Islanders constitute a relatively small portion of the Gulf Coast population (3.1%), this group has experienced a growth rate of 19.5 percent between 2005 and 2010. The proportion of white population has remained fairly constant and in 2010 constitutes 51.4 percent of the area's population. These overall trends vary from one EIA to another and from one Gulf Coast State to another.

Differences in age structure, as well as net migration, among the coastal EIA's could create variations in population growth. The highest rates of population growth between 2010 and 2040 are expected in Texas EIA's (TX-1 at 63%) and Florida EIA's (FL-1 at 54.4%) and the lowest are expected in Alabama, Mississippi, and Louisiana EIA's (LA-1 is the lowest at 18.3%).

The racial and ethnic composition of the analysis area reflects both historical settlement patterns and current economic activities. For example, those areas in Texas where Hispanics are the dominant group—EIA TX-1 where they represent 81 percent of the population—were also first settled by people from Mexico. Their descendants remain, many of whom work in farming, tending cattle, or in low-wage industrial jobs. By TX-3, the size of the African-American population increases, and there is a more diversified racial mix indicating more urban and diverse economic pursuits. In Louisiana, Mississippi, Alabama, and Northern Florida (FL-1 and FL-2), African-Americans outnumber Hispanics, reflecting the dominant minority status of African-Americans throughout much of the analysis area. A more detailed discussion of minority populations in the area can be found in **Chapter 4.1.1.21.4.1**.

Table 4-37 presents the baseline population projections used to analyze the impacts of the CPA proposed action and the OCS Program (which, as explained in **Chapter 4.1.1.21.2.4** is used for the cumulative impact analysis). As stated above, these baseline projections assume the continuation of existing social, economic, and technological trends at the time of the forecast (i.e., prior to the DWH event and the subsequent drilling suspensions). However, this data still remain the best long-term forecast of regional trends for socioeconomic impact analyses of the CPA proposed action.

4.1.1.21.2.2. Impacts of Routine Events

Background/Introduction

A detailed description of routine impacts on demographics associated with the CPA proposed action can be found in Chapter 4.2.2.1.15.2 of the Multisale EIS and in Chapter 4.1.16.2 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in these documents and incorporates new information found since their publication.

The addition of any new human activity, such as oil and gas development resulting from the CPA proposed action, can affect local communities in a variety of ways. Typically, these effects are in the form of people and money, which can translate into changes in the local social and economic institutions. Minor demographic changes, primarily in focus areas, are projected as a result of the CPA proposed action.

Proposed Action Analysis

Population

Projected population changes reflect the number of people dependent on income from OCS-related employment for their livelihood (i.e., family members of oil and gas workers). The population projections due to the CPA proposed action are calculated by multiplying the employment projections for the sale (**Chapter 4.1.1.21.3.2**) by a ratio of baseline population to baseline employment (**Tables 4-37 and 4-38**). The CPA proposed action is projected to generate from 12,400 to 35,900 persons in the entire analysis area during the peak impact year (model year 5 or 2016) for the low- and high-case scenarios, respectively. While population associated with the proposed sale is projected to peak in year 5, years 2 and 6 also display high levels. During these years, a substantial amount of platform and pipeline installations are projected in association with the proposed sale. Platform fabrication and installation, and pipeline installation activities are labor intensive and tend to occur concurrently, leading to more substantial employment and population impacts.

Using the new Woods & Poole Economics, Inc. (2010) data discussed above as the baseline, BOEMRE recalculated the population impacts on a percentage basis. The revised numbers do not differ substantially from those presented in Table 4-29 of the Multisale EIS and mirror those for employment impacts discussed in **Chapter 4.1.1.21.3.2**. Population impacts from the CPA proposed action are expected to be minimal (less than 1% of total population) for any EIA in the Gulf of Mexico region. The increase in employment is expected to be met primarily with the existing population and labor force, with the exception of some in-migration projected to move into such focal areas as Port Fourchon.

Age

The age distribution of the analysis area as a result of the CPA proposed action is projected to remain virtually unchanged. Given both the low levels of population growth and industrial expansion associated with the proposed action, the age distribution pattern discussed above in **Chapter 4.1.1.21.2.1** is expected to continue through the life of the CPA proposed action. The proposed CPA lease sale is not expected to affect the analysis area's median age.

Race and Ethnic Composition

The racial distribution of the analysis area is projected to remain virtually unchanged as a result of the CPA proposed action. Given the low levels of employment and population growth and the industrial expansion projected as a result of the proposed action, the racial distribution pattern described above in **Chapter 4.1.1.21.2.1** is expected to continue through the life of the CPA proposed action.

Summary and Conclusion

The CPA proposed action is projected to minimally affect the demography of the analysis area. Population impacts from the proposed action are projected to be minimal (<1% of the total population) for any EIA in the Gulf of Mexico region. The baseline population patterns and distributions, as projected and described in **Chapter 4.1.1.21.2.1**, are expected to remain unchanged as a result of the CPA proposed action. The increase in employment is expected to be met primarily with the existing population and available labor force, with the exception of some in-migration projected to occur in focal areas, such as Port Fourchon.

4.1.1.21.2.3. Impacts of Accidental Events

Accidental events associated with the CPA proposed action, such as oil or chemical spills, blowouts, and vessel collisions, would likely have no effects on the demographic characteristics of the Gulf coastal communities. This is because net employment impacts from a spill are not expected to exceed 1 percent of baseline employment for any EIA in any given year even if they are included with employment associated with routine oil and gas development activities associated with the CPA proposed action and if population changes are derived from employment changes.

In the case of a catastrophic spill, there may be some out-migration from some affected areas in the region if there are substantial long-term employment impacts to the tourism and recreation, fishing, or energy industries in the area. For further discussion on the employment and demographic impacts of a catastrophic spill, see **Appendix B**.

4.1.1.21.2.4. Cumulative Impacts

Background/Introduction

A detailed discussion of the cumulative impacts to demographics can be found in Chapter 4.5.15.2 of the Multisale EIS and in Chapter 4.1.16.2.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in these documents, and it incorporates new information found since their publication. The cumulative analysis considers the effects of OCS-related, impact-producing factors as well as non-OCS-related factors on demographics. The OCS-related factors consist of population and employment from prior, current, and future OCS lease sales. Non-OCS factors include fluctuations in workforce, net migration, relative income, oil and gas activity in State waters, and offshore LNG activity. Not considered in this analysis are the unexpected events that may influence oil and gas activity within the analysis area that cannot be predicted with reasonable accuracy. Examples of unexpected events include oil embargos and acts or war or terrorism.

Most approaches to analyzing cumulative effects begin by assembling a list of “other likely projects and actions” that will be included with the proposed action analysis. However, no such list of future projects and actions could be assembled that would be sufficiently current and comprehensive to support a cumulative analysis for all 132 of the coastal counties and parishes in the analysis area over a 40-year period. Instead, this analysis uses the economic and demographic projections from Woods & Poole Economics, Inc. (2010) to define the contributions of other likely projects, actions, and trends to the cumulative case. These projections include population associated with the continuation of current patterns of OCS leasing activity as well as the continuation of trends in other industries important to the region. The same methodology used to project changes to population from routine activities associated with the CPA proposed action is used to examine impacts of the OCS Program in the region.

Population

Population impacts from the OCS Program (Table 4-43 in the Multisale EIS) remain unchanged because the exploration and development scenarios for the OCS Program did not change for this document (and thus the employment projections related to the OCS Program did not change). Projected population changes reflect the number of people dependent on income from oil- and gas-related employment for their livelihood (i.e., family members of oil and gas workers). Activities associated with the OCS Program are projected to have minimal effects on population in most of the EIA’s. Lafourche Parish (EIA LA-3) and Lafayette Parish (EIA LA-2) in Louisiana, in particular, are projected to experience noteworthy increases in population resulting from increases in demand for OCS labor. Chapter 4.5.15.3 of the Multisale EIS discusses this issue in more detail.

Using the new Woods & Poole Economics, Inc.’s data (2010) discussed above as the baseline, BOEMRE recalculated the population impacts of the OCS Program on a percentage basis. These revised numbers do not differ substantially from those presented in Table 4-44 of the Multisale EIS and mirror those discussed for OCS Program employment in **Chapter 4.1.1.21.3.4**.

Age

Cumulative activities are projected to leave the age distribution of the analysis area virtually unchanged. Given both the low levels of population growth and the industrial expansion associated with the cumulative activities, it is projected that the age distribution pattern discussed above in **Chapter 4.1.1.21.2.1** will likely continue throughout the analysis period.

Race and Ethnic Composition

Cumulative activities are projected to leave the racial distribution of the analysis are virtually unchanged. Given the low levels of employment and population growth and the industrial expansion projected for the cumulative activities, the racial distribution pattern discussed above in **Chapter 4.1.1.21.2.1** is projected to continue throughout the analysis period.

Summary and Conclusion

The cumulative activities are projected to minimally affect the analysis area's demography. Baseline patterns and distributions of these factors, as described in **Chapter 4.1.1.21.2.1**, are not expected to change for the analysis area as a whole. Lafourche Parish (EIA LA-3), including Port Fourchon, and Lafayette Parish (EIA LA-2) in Louisiana are projected to experience noteworthy impacts to population as a result of an increase in demand for OCS labor from the OCS Program. The CPA proposed action is projected to have an incremental contribution of less than 1 percent to the population level in any of the EIA's. Given both the low levels of population growth and industrial expansion associated with the proposed action, it is expected that the baseline age and racial distribution pattern would continue through the analysis period.

4.1.1.21.3. Economic Factors

In light of the recent DWH event, BOEMRE has reexamined the analysis of economic factors presented in the Multisale EIS and the 2009-2012 Supplemental EIS. While some new information was found related to the baseline employment conditions (most notably the new Woods & Poole Economics, Inc. (2010) data on projections for employment), the incremental employment impacts of the CPA proposed action, and the impacts of accidental events, a reanalysis found that none of the new information altered the impact conclusions for employment presented in the Multisale EIS and the 2009-2012 Supplemental EIS. It is too early to determine if there will be any significant long-term employment changes in the region as a result of the DWH event and the subsequent drilling suspensions. Given current information, BOEMRE anticipates that there may be some long-term employment changes in some counties and parishes in the region. However, at this time, it is not clear if these changes will be significant or not. The BOEMRE will continue to monitor data and information on employment as it becomes available. Short-term employment impacts and potential long-term employment impacts related to the DWH event in general and the drilling suspensions in particular are discussed at the end of the sections below on the "Description of the Affected Environment" (**Chapter 4.1.1.21.3.1**) and "Impacts of Accidental Events" (**Chapter 4.1.1.21.3.3**). The following sections focus on the employment impacts to the energy industries and offshore support industries in the EIA's. The employment impacts to commercial fishing (**Chapter 4.1.1.17**), recreational fishing (**Chapter 4.1.1.18**), and tourism and recreation (**Chapter 4.1.1.19**) are discussed in detail within their individual sections.

A detailed description of the affected environment and full analyses of the potential impacts of routine activities and accidental events associated with the CPA proposed action are presented in the Multisale EIS and the 2009-2012 Supplemental EIS, as are the proposed action's incremental contribution to the cumulative impacts. A summary of those analyses and their reexamination due to new information and the DWH event and drilling suspensions are presented in the following sections.

A brief summary of potential impacts follows. Should the CPA proposed action occur, there would be only minor economic changes in the Texas, Louisiana, Mississippi, Alabama, and Florida EIA's. The proposed action is expected to generate less than a 1 percent increase in employment in any of the coastal subareas, even when the net employment impacts from accidental events are included. Most of the employment related to the proposed action is expected to occur in Texas and Louisiana. The labor demand would be met primarily with the existing population and labor force. The cumulative activities are projected to minimally affect the analysis area's economic conditions.

4.1.1.21.3.1. Description of the Affected Environment

The description of the environment for economic factors is described in Chapter 3.3.5.5 of the Multisale EIS and in Chapter 4.1.16.3.1 of the 2009-2012 Supplemental EIS. The following is a

summary and update of the information presented in those documents. A search was conducted for new information since completion of the Supplemental EIS that would impact the baseline economic factors of the region. The BOEMRE examines economic impacts over the 40-year life of the proposed action. The new 2011 CEDDS data from Woods & Poole Economics, Inc. (2010) was most relevant to this examination, and BOEMRE updated all baseline projections using these data. The limited supplemental information related to the short-term impacts of the DWH event and the drilling suspensions that is available is presented at the end of this section. However, this supplemental information does not change the Woods & Poole Economics, Inc.'s baseline employment projections used to analyze impacts of the CPA proposed action and the OCS Program, which, as explained in **Chapter 4.1.1.21.3.4**, is used for the cumulative impact analysis. The methodology BOEMRE uses to measure employment impacts (and subsequent demographic impacts) over the 40-year life of the proposed lease sale recognizes that most of the employment that results from industry activities that result from the lease sale is not generated until 4-7 years after the sale. In contrast, the supplemental information provided below is related to current socioeconomic conditions.

Offshore waters of the WPA, CPA, and EPA lie adjacent to coastal Texas, Louisiana, Mississippi, Alabama, and Florida. The BOEMRE grouped sets of counties and, in Louisiana, parishes into LMA's on the basis of intercounty commuting patterns. Twenty-three of these LMA's span the Gulf Coast and comprise the 13 BOEMRE-defined EIA's. **Table 4-23** lists the counties and parishes that comprise the LMA's and EIA's, and **Figure 2-2** illustrates the counties and parishes that comprise the EIA's; see Chapter 3.3.5.4.1 of the Multisale EIS for further detail. The nature of the offshore oil and gas industry is such that the same onshore economic impact area is used to examine leasing activities in both the WPA and CPA. First, workers commute long distances for rotations offshore that last for 2-3 weeks at a time, and there is great flexibility between where employees live in the region and where they work offshore in the GOM. Second, industry equipment and supplies for offshore projects in both planning areas come from throughout the region. Although the same overall economic impact area is used to analyze sales in both planning areas, the economic impacts to the different individual EIA's do vary between WPA sales and CPA sales.

Tables 3-18 through 3-30 of the Multisale EIS provide current and baseline projections for employment, income and wealth, and business patterns for the EIA's using 2006 CEDDS data (Woods & Poole Economics, Inc., 2006). **Tables 4-24 through 4-36** provide updated projections of the data using the 2011 CEDDS data (Woods & Poole Economics, Inc., 2010). Average annual employment growth projected from 2010 to 2040 range from a low of 1.03 percent for EIA MS-1 to a high of 2.04 percent for EIA FL-1 in the western panhandle of Florida. Over the same time period, employment for the U.S. is expected to grow at about 1.39 percent per year, while the GOM economic impact analysis area as a whole is expected to grow at about 1.79 percent per year.

The Woods & Pool Wealth Index is a measure of relative wealth, with the U.S. having a value of 100. The Wealth Index is the weighted average of regional income per capita divided by U.S. income per capita (80% of the index), plus the regional proportion of income from dividends/interest/rent divided by the U.S. proportion (10% of the index), plus the U.S. proportion of income from transfers divided by the regional proportion (10% of the index). Thus, relative income per capita is weighted positively for a relatively high proportion of income from dividends, interest, and rent, and negatively for a relatively high proportion of income from transfer payments. In 2010, all EIA's within the GOM analysis area with the exception of FL-4 (which had an index of 113.4) ranked below the U.S. in terms of wealth. The next two highest EIA's were LA-4 and TX-3, with indices of 91.9 and 87.4, respectively. The EIA FL-2 ranked the lowest of all EIA's, with an index of 66.8. The Florida EIA's comprise the portion of the analysis area that is least influenced by OCS development. The EIA's with the next lowest wealth indices are AL-1 and MS-1, with indices of 71.9 and 73.6, respectively.

Of the 132 counties that comprise the GOM region's economic analysis area, 19 ranked above the U.S. (6 in FL-4; 4 in LA-4; 3 in TX-3; 2 in LA-1; and 1 in LA-2, TX-1, FL-1, and FL-3). Monroe County in FL-4 was the highest, with an index of 157.91. The lowest county is Starr County in TX-1 with an index of 42.12, followed by Greene County in MS-1 with 50.92 and Hamilton County in FL-2 with 51.76.

As shown in **Tables 4-24 through 4-36**, the industrial composition for the EIA's is similar. In 2010, all of the EIA's had State and Local Government and Retail Trade as one of their top five ranking sectors in terms of employment, and all of them except MS-1 had Health Care and Social Assistance as one of their top five. Accommodation and Food Services is one of the top five sectors for seven of the EIA's

(TX-1, LA-1, LA-3, LA-4, MS-1, FL-1, and FL-2). As part of its economic impact analysis in **Chapter 4.1.1.21.3.2**, BOEMRE uses regional input-output multipliers from the commercial software IMPLAN. A set of multipliers is created for each EIA in the analysis area based on each EIA's unique industry make-up. An assessment of the change in overall economic activity for each EIA is then modeled as a result of the expected changes in economic activity associated with holding the CPA proposed action.

Table 4-38 presents the baseline employment projections used to analyze the impacts of the CPA proposed action and the OCS Program which, as explained in **Chapter 4.1.1.21.3.4**, is used for the cumulative impact analysis). These baseline projections assume the continuation of existing social, economic, and technological trends at the time of the forecast. Therefore, the projections include employment associated with the OCS leasing patterns and other industry trends that were prevalent prior to the DWH event and the subsequent drilling suspensions. However, this data still remains the best long-term forecast of regional trends for socioeconomic impact analyses of the CPA proposed action.

Deepwater Horizon Event

Tracking the economic and employment impacts in the GOM region as a result of the DWH event will be a long-term and difficult task. Many of the potentially affected jobs, like fishing charters, are self-employed. Thus, they will not necessarily file for unemployment and will not be included in business establishment surveys used to estimate State unemployment levels. In addition, unemployment numbers in states are based on nonagricultural jobs, and the fishing industry is considered within the agriculture category. On the other side, it is also a challenge to estimate how many of these displaced workers have been hired to clean up the spill. Furthermore, the extent of the geographic areas that will be affected economically in the long-term is unknown, as is how long the impacts will last (e.g., if fisheries are irreparably damaged, affected fishermen will have no jobs to go back to).

On May 6, 2010, this Agency announced a deepwater drilling moratorium to last through the month; however, it was extended 6 months to November 30, 2010. The May moratorium had the effect of suspending activity at all 33 rigs developing exploratory wells in deepwater. This posed new hardships for hundreds of oil-service companies that supply the steel tubing, engineering services, drilling crews and marine-supply boats critical to offshore exploration. Early estimates varied concerning the potential economic and employment impacts of the moratorium varied. David Dismukes, of LSU's Center for Energy Studies, estimated as many as 35,000 jobs could be affected (Hargreaves, 2010). The Louisiana Mid-Continent Oil and Gas Association estimated a total of 800-1,400 jobs per idle rig platform were at risk, or roughly 34,400-60,000 throughout the Gulf economy (Louisiana Mid-Continent Oil and Gas Association, 2010). The Louisiana Department of Economic Development estimated that if the suspension of active drilling activity continued for an extended period, the State risked losing more than 20,000 existing and potential jobs over a 12- to 18-month period (Jindal, 2010). Lawrence R. Dickerson, the Chief Executive of Diamond Offshore Drilling, which owns six deepwater rigs in the Gulf, stated that 15,000-20,000 rig and associated service jobs were at risk during this period (Zeller, 2010).

Roubini Global Economics (Teslik and Menegatti, 2010) estimated that the economic consequences of the spill will lead to a net loss of just under $20 billion for the U.S. economy in 2010, which will lower U.S. economic growth in 2010 by roughly 0.1 percent and will lower growth in the four states most affected (Louisiana, Mississippi, Alabama, and Florida) by 1.6 percent of their combined gross domestic product. They estimated that the oil and gas industry was likely to suffer the most from the spill ($9 billion including impacts of a deepwater drilling suspension and impacts to oil and gas support industries), followed by tourism ($8.4 billion regionwide, with Louisiana and Florida taking the biggest losses), and fishing ($1.2 billion). An economist at Wells Fargo estimated that up to 250,000 Gulf jobs in fishing, tourism, and energy would be lost in the second half of the year (Aversa, 2010). It was estimated that in total, the new jobs in cleanup would not make up for what had been lost and would likely pay less (e.g., $15-18/hr compared with roughly $45/hr on a drilling rig), so consumers in the region would likely spend less as a result (Aversa, 2010). However, the degree to which new cleanup jobs offset job losses would vary greatly from county-to-county/parish-to-parish. As of July 6, 2010, more than 45,000 personnel were working on the response effort (RestoreTheGulf.gov, 2010a).

As more information became available, estimates of the impacts of the DWH event changed. An Inter-Agency Report on the economic effects of the deepwater drilling suspension on the Gulf Coast economy in September found that there had not been large increases in unemployment. Recipients of

unemployment insurance in three states had been asked whether their claims were related to the drilling suspensions. Based on the responses through September 13, 2010, only 734 suspension-related continuing claims had been filed in Louisiana, 22 in Mississippi, and 64 in Texas (for a total of 820). As noted previously, however, self-employed persons are not eligible for unemployment insurance and are thus not reflected in the data. The report estimated that during the 6-month period an average of 2,000 rig workers would have been laid off or left the Gulf Coast, or about 20 percent of the rig workers employed in the GOM prior to the DWH event. The report also estimated that total operator spending on leasing vessels, supplies, services, and materials would be reduced by about $1.95 billion as a result of the suspension, affecting the network of onshore businesses that serve the deepwater drilling economy. Including multiplier impacts, the report estimated that up to 8,000-12,000 jobs may be temporarily lost, but that most would return following the resumption of deepwater drilling in the GOM. As stated, deepwater drilling has resumed, and the pace of permit issuance will determine the rate at which these jobs become available.

As of April 8, 2011, 10 permits for deepwater drilling have been awarded. At the end of November, 27 jackups were actually working, only 5 of 25 semisubmersibles were working and only one of 11 drillships (Greenberg, 2010). Day rates for large, deepwater, supply vessel operators dropped from an average $14,787 a day in October to $11,500 in November, and utilization fell from 89 percent to 81 percent (Greenberg, 2010). As of December 2010, only three deepwater rigs had exited the Gulf since the deepwater suspension was implemented. However, the post-suspension delay in the resumption of operations was continuing, increasing the possibility that more rigs will leave the Gulf in the future. In addition, the offshore industry also continues to face compliance with new regulations and higher insurance costs, and these may potentially lead to lower levels of industry activity than prevailed prior to the DWH event. According to one annual study for Louisiana, Lafayette and Houma-Thibodaux face employment drops because of a projected slowdown in the Gulf oil and natural gas activity. The report projects a loss of 3,000 (2%) jobs in 2011 and another 800 (0.6%) in 2012 for Lafayette. Houma-Thibodaux is forecast to have a 1,500 job loss (1.7%) in 2011 and another 500 (0.5%) in 2012 (Sayre, 2010). The report also warns that the planned closing of the Northrop Grumman Corp. shipyard in suburban Avondale, which currently employs about 4,400, will be felt in early 2013 in the New Orleans area (Sayre, 2010).

State figures show that employment remained relatively steady in Louisiana in August, September, and October, and oil and gas employment remained fairly constant (Schmidt, 2010a and 2010b; Magill, 2010). To date, the suspension has not triggered the significant economic impacts that were originally estimated (and described in the preceding paragraphs). Even though many deepwater rigs that remain in the GOM are not currently working, drilling contractors have decided, to date, to retain most of their crews in the interest of holding on to drilling expertise in the hope of restarting quickly once they are able. Similarly, rig operators and well servicing firms have largely retained their employees (USDOC, 2010). Many employers have been keeping their workers busy doing maintenance and repair work. Although the official numbers have not changed much, the State's count of workers does not track the cuts to hours and benefits that oilfield workers claim they have been experiencing as a result of the deepwater-drilling ban. There is evidence of some increased demand for assistance in affected areas as a result of those cuts (Schmidt, 2010a). Also, in the absence of active drilling, companies have no need for certain kinds of services and equipment, and this affects the revenues (and employment levels) of many small businesses in the area (Nolan, 2010). Companies, particularly independents and small businesses, have been unable to make new, important investments, have stopped hiring workers, and have been forced to drain their reserves while they sit and wait (Broder, 2010). Smaller or nonexistent paychecks also add up to less tax revenues along the Gulf Coast.

In addition to the small businesses, another group that has been hard hit in recent months has been the shallow-water rig workers who, unlike their deepwater counterparts, are ineligible for the $100 million Rig Worker Assistance Fund established by BP and administered by the Baton Rouge Area Foundation. While there was no suspension of shallow-water drilling, it has been affected by permitting delays. According to a spokesman for the advocacy group Shallow Water Energy Security Coalition, some 500 workers were laid off across the shallow-water sector through October (December 2010). Shallow-water driller's woes are aggravated by the fact that these rigs operate on contracts with oil companies ranging from a few days to a few months. While idle deepwater rigs, which are leased out for years, keep bringing in cash for their owners, shallow-water rigs are in limbo when contracts end. According to

Dr. Dismukes at Louisiana State University, 624 deepwater rig workers started the application with the Baton Rouge Area Foundation, but only 343 provided a complete package (Dismukes, personal communication, 2010e).

To date, U.S. State and local governments are also faring far better than forecast, largely because of massive cleanup spending, according to Moody's Investor Service (Connor, 2010). Moody's had named 59 debt issues that might have been affected by the oil disaster, which had raised fears that populations might decline and that local property values and tax revenue would be decreased. Moody's reports that its analysts had determined that vital government revenue, such as property taxes, utility charges, and State school district funding, had broadly held up and that the fiscal pressures have been manageable and are not likely to be of a long-term nature (Connor, 2010).

Whatever the actual numbers turn out to be, much of the employment loss will be concentrated in coastal oil-service parishes in Louisiana (St. Mary, Terrebonne, Lafourche and Plaquemines Parishes) and counties/parishes where drilling-related employment is most concentrated (Harris County, Texas [Houston]; Lafayette and Iberia Parishes, Louisiana) (Nolan and Good, 2010; U.S. Dept. of Labor, Bureau of Labor Statistics, 2010b; USDOC, 2010). The BOEMRE will continue to monitor Federal, State, and public data and analyses conducted on the economic and employment impacts of the spill and provide updated information as it becomes available. As noted above, additional detailed information on employment impacts to commercial fishing, recreational fishing, and tourism can also be found in **Chapters 4.1.1.17, 4.1.1.18,** and **4.1.1.19** of this Supplemental EIS.

4.1.1.21.3.2. Impacts of Routine Events

Background/Introduction

The detailed description of possible impacts on economic factors, primarily employment, from routine activities associated with the CPA proposed action is given in Chapter 4.2.2.1.15.3 of the Multisale EIS and in Chapter 4.1.16.3.2 of the 2009-2012 Supplemental EIS. The economic analysis for the CPA proposed lease sale focuses on the potential direct, indirect, and induced impacts of the OCS oil and gas industry on the population and employment of the counties and parishes in the analysis region defined in Chapter 3.3.5.1 of the Multisale EIS.

Proposed Action Analysis

Tables 4-30 and 4-31 of the Multisale EIS provide the low- and high-case employment projections for the CPA proposed action by economic impact area over the 40-year life. Because of the changes made to the exploration and development scenarios used in the analysis of the CPA proposed action, BOEMRE made corresponding adjustments to the employment projections. Based on these adjustments, direct employment (for the entire economic impact area) associated with the CPA proposed action is approximately 3,365-10,155 during the peak impact year for the low- and high-case scenarios. Indirect employment is projected at about 1,455-4,050 jobs, while induced employment is calculated to be about 2,275-6,385. Thus, total employment in the EIA resulting from the CPA proposed action is not expected to exceed 7,095-20,590 jobs in any given year over the proposed action's 40-year lifetime. Most of the employment related to the CPA proposed action is expected to occur in Texas (EIA TX-3) and Louisiana (EIA's LA-2, LA-3, and LA-4). It should be emphasized, however, that a portion of these estimates do not represent "new" jobs; many of these would represent new contracts or orders at existing firms that would essentially keep the firm operating at its existing level as earlier contracts and orders are completed and filled. In other words, a portion of these 7,095-20,590 jobs would be staffed with existing company labor force and would simply maintain the status quo. Thus, these estimates may overestimate the actual magnitude of new employment effects from the proposed action. Considering Florida's current opposition to oil and gas development in offshore waters and the scarcity, if not absence, of onshore supporting service bases, BOEMRE anticipates that very few OCS-related activities would be staged from Florida.

Using the new Woods & Poole Economics, Inc. (2010) data discussed above as the baseline, BOEMRE recalculated the employment impacts on a percentage basis. The revised numbers do not differ substantially from those presented in the Multisale EIS and the 2009-2012 Supplemental EIS. Employment is not expected to exceed 1 percent of total employment in any given EIA of Texas,

Louisiana, Mississippi, Alabama, or Florida. On a percentage basis, LA-2 and LA-3 are still projected to have the greatest employment impacts at 1 percent and 0.5 percent, respectively. On a percentage basis, EIA LA-4 is still projected to have the next greatest impact at 0.3 percent, followed by TX-3 and LA-1 at 0.2 percent.

Summary and Conclusion

Should the CPA proposed action occur, there would be only minor economic changes in the Texas, Louisiana, Mississippi, Alabama, and Florida EIA's. This is because the demand would be met primarily with the existing population and labor force. The CPA proposed action is expected to generate less than a 1 percent increase in employment in any of these subareas. Most of the employment related to the CPA proposed action is expected to occur in Texas (EIA TX-3) and Louisiana (EIA's LA-2, LA-3, and LA-4).

4.1.1.21.3.3. Impacts of Accidental Events

Background/Introduction

A detailed description of the possible impacts from accidental events associated with the CPA proposed action on economic factors, primarily employment, is presented in Chapter 4.4.14.3 of the Multisale EIS and in Chapter 4.1.16.3.3 of the 2009-2012 Supplemental EIS. Accidental events associated with the CPA proposed action, such as oil or chemical spills, blowouts, and vessel collisions, would likely have minimal, if any, net effects on employment.

Proposed Action Analysis

Chapters 4.3.1.5, 4.3.1.6, and 4.3.4 of the Multisale EIS depict the risks and number of spills estimated to occur for the proposed action. The probabilities of an offshore spill ≥1,000 bbl occurring and contacting coastal counties and parishes was used as an indicator of the risk of a slick from such a spill reaching sensitive coastal environments. Figure 3-7 of the 2009-2012 Supplemental EIS shows the Gulf of Mexico coastal counties and parishes having a risk of >0.5 percent of being contacted within 10 days by an offshore oil spill ≥1,000 as a result of the CPA proposed action. Most counties and parishes have a <0.5 percent probability of an oil spill ≥1,000 bbl occurring and contacting (combined probability) their shorelines within 10 days; two counties in Texas and eight parishes in Louisiana have a 1-16 percent chance of an OCS offshore oil spill ≥1,000 bbl occurring and reaching their shoreline within 10 days as the result of the proposed action over its 40-year life. In Louisiana, Plaquemines Parish has the greatest risk (10-16%) of being contacted within 10 days by an oil spill occurring offshore as a result of the CPA proposed action. The BOEMRE estimates that between 5 and 15 chemical spills associated with the OCS Program are anticipated each year, with a small percentage of these associated with the proposed action. The majority of spills are expected to be <50 bbl in size; a chemical spill of ≥1,000 bbl as a result of the proposed action or OCS Program is very unlikely.

The immediate social and economic consequences for the region in which a spill occurs are a mix that includes not only additional opportunity cost jobs and sales but also nonmarket effects such as traffic congestion, strains on public services, shortages of commodities or services, and disruptions to the normal patterns of activities or expectations. These negative short-term social and economic consequences of a spill are expected to be modest as measured by projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Negative long-term economic and social impacts may be more substantial if fishing, shrimping, oystering, and/or tourism were to suffer or were to be perceived as having suffered because of the spill, or if there were substantial changes to the energy industries in the region as a result of the spill. Additional information on employment impacts to commercial fishing, recreational fishing, and tourism from accidental events can be found in **Chapters 4.1.1.17, 4.1.1.18,** and **4.1.1.19** of this Supplemental EIS. For a discussion of the employment impacts of catastrophic spill, see **Appendix B**.

Net employment impacts from a spill are not expected to exceed 1 percent of baseline employment for any EIA in any given year even if they are included with employment associated with routine oil and gas development activities associated with the CPA proposed action. The employment impacts from a vessel collision are likely to be shorter term and less than those from a spill.

Summary and Conclusion

The short-term social and economic consequences for the Gulf coastal region should a spill ≥1,000 bbl occur includes the opportunity cost of employment and expenditures that could have gone to production or consumption rather the spill cleanup efforts. Nonmarket effects such as traffic congestion, strains on public services, shortages of commodities or services, and disruptions to the normal patterns of activities or expectations are also expected to occur in the short term. These negative, short-term social and economic consequences of a spill are expected to be modest in terms of projected cleanup expenditures and the number of people employed in cleanup and remediation activities. Negative, long-term economic and social impacts may be more substantial if fishing, shrimping, oystering, and/or tourism were to suffer or were to be perceived as having suffered because of the spill or if there were substantial changes to the energy industries in the region as a result of the spill. Net employment impacts from a spill are not expected to exceed 1 percent of baseline employment for any EIA in any given year even if they are included with employment associated with routine oil and gas development activities associated with the CPA proposed action.

4.1.1.21.3.4. Cumulative Impacts

Background/Introduction

A detailed discussion of the cumulative impacts to economic factors, primarily employment, can be found in Chapter 4.5.15.3 of the Multisale EIS and in Chapter 4.1.16.3.4 of the 2009-2012 Supplemental EIS. The following is a summary of the information presented in these documents and incorporates new information found since their publication.

The cumulative economic analysis focuses on the potential direct, indirect, and induced employment impacts of the OCS Program's oil and gas activities in the Gulf of Mexico, together with those of other likely future projects, actions, and trends in the region. Most approaches to analyzing cumulative effects begin by assembling a list of "other likely projects and actions" that will be included with the proposed action for analysis. However, no such list of future projects and actions could be assembled that would be sufficiently current and comprehensive to support a cumulative analysis for all 132 of the coastal counties and parishes in the analysis area over a 40-year period. Instead of an arbitrary assemblage of future possible projects and actions, the analysis employs the economic and demographic projections from Woods & Poole Economics, Inc. (2010) to define the contributions of other likely projects, actions, and trends to the cumulative case. These projections are based on local, regional, and national trend data as well as likely changes to local, regional, and national economic and demographic conditions. Therefore, the projections include employment associated with the continuation of current patterns in OCS leasing activity as well as the continuation of trends in other industries important to the region. These Woods & Poole Economics, Inc.'s projections represent a more comprehensive and accurate appraisal of cumulative conditions than could be generated using the traditional list of possible projects and actions. The same regional economic impact assessment methodology used to estimate changes to employment from the proposed lease sale was used for the cumulative analysis. Using the new Woods & Poole Economics, Inc. (2010) data discussed above as the baseline, BOEMRE recalculated the employment impacts of the OCS Program on a percentage basis. These revised numbers do not differ significantly from those presented in the Multisale EIS.

Tables 4-45 and 4-46 of the Multisale EIS present projected employment associated with the OCS Program. These projections have not changed for this analysis, as the exploration and development scenarios associated with the OCS Program did not change. Based on the model results, direct employment in the BOEMRE-defined EIA associated with OCS Program activities is estimated to range between 126,000 and 160,000 jobs during peak activity years for the low and high resource estimate scenarios, respectively. Indirect employment is projected between 48,000 and 62,000 jobs, while induced employment is projected between 83,000 and 106,000 jobs for the same period. Therefore, total employment resulting from OCS Program activities in the BOEMRE-defined EIA is not expected to exceed 257,000-328,000 jobs in any given year over the 40-year analysis period.

In Texas, the majority of OCS-related employment is expected to occur in EIA TX-3, which also represents the largest projected employment level of any EIA. This employment is expected to never exceed a maximum of 2.2 percent of total employment in that EIA. The OCS-related employment for

EIA's LA-2, LA-3, and LA-4 is also projected to be substantial. Direct employment levels in LA-2 and LA-3 are comparable, with LA-2 slightly higher. However, the impacts on a percentage basis are much higher in LA-2, reaching a maximum of nearly 20.3 percent versus about 8 percent in LA-3. However, the percentage analysis is highly dependent on the baseline employment projections, which are dependent on the size of the EIA. The EIA LA-2 has one labor market area (Lafayette) while LA-3 has two labor market areas (Baton Rouge and Houma). It follow that the baseline employment projections for LA-2 are less than (in this case, less than half) the baseline employment projections for LA-3 and that the resulting percentage impacts in LA-2 are more than twice as high. Nonetheless, over the last decade there has been a migration to Lafayette Parish (and to a lesser extent Iberia Parish) from areas throughout coastal Louisiana, particularly in the extraction and oil and gas support sectors. The next greatest impacts in percentage terms are in LA-4, LA-1, TX-3 and TX-2, respectively, with none exceeding 5 percent in any given year. The OCS-related employment for TX-1 and all of the Alabama, Mississippi, and Florida EIA's is not expected to exceed 2 percent of the total employment in any EIA.

Employment demand will continue to be met primarily with the existing population and available labor force in most EIA's. The vast majority of these cumulative employment estimates represent existing jobs from previous OCS-Program actions. The BOEMRE does expect some employment will be met through in-migration; however, this level is projected to be small and localized and, thus, BOEMRE expects the sociocultural impacts from in-migration to be minimal in most EIA's. Peak annual changes in the population, labor, and employment of all EIA's resulting from the OCS Program are minimal, except in some parts of Louisiana. As discussed in **Chapter 4.1.1.21.3.2**, the CPA proposed action is expected to have an incremental contribution of <1 percent to the employment level in any of the EIA's.

Summary and Conclusion

The OCS Program will produce only minor economic changes in the Texas, Mississippi, Alabama, and Florida EIA's. The OCS Program is expected to represent <2.2 percent of employment projected in the EIA's in these states. However, the OCS Program is projected to substantially impact LA-2 and LA-3, with OCS-related employment expected to peak at 20.3 percent and 8 percent of total employment, respectively. As discussed in **Chapter 4.1.1.21.3.2**, the CPA proposed action is expected to have an incremental contribution of <1 percent to the employment level in any of the EIA's.

4.1.1.21.4. Environmental Justice

The BOEMRE has reexamined the analysis for environmental justice presented in the Multisale EIS and the 2009-2012 Supplemental EIS, based on the additional information presented below and in consideration of the DWH event. No substantial new information was found that would alter the impact conclusion for environmental justice presented in the Multisale EIS and the 2009-2012 Supplemental EIS.

On February 11, 1994, President Clinton issued Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, which directs Federal agencies to assess whether their actions have disproportionate environmental effects on people of ethnic or racial minorities or people living below the poverty line. Those environmental effects encompass human health, social, and economic consequences. The BOEMRE has examined environmental justice for the CPA proposed action and has provided opportunities for community input during the NEPA process (See **Chapter 5** for a discussion of scoping and community consultation and coordination.).

Environmental justice is a complex issue, and although methodologies have evolved to assess whether an environmental injustice has taken place, this type of analysis still poses challenges, particularly when considering OCS leasing decisions. First, the OCS Program in the Gulf of Mexico is large and has been ongoing for more than 50 years. During this period, substantial leasing has occurred off Texas, Louisiana, Mississippi, and Alabama. The OCS lease sales occur in Federal waters 3 mi (5 km) or more from shore; thus, the resulting exploration, extraction, and production activities on leaseholds are distant from human habitation. State offshore oil and gas leases are closer to land and their petroleum-related activities in State waters are generally viewed as having a greater potential for directly impacting coastal communities. Second, most OCS sale-related impacts that potentially might affect environmental justice are indirect, arising onshore as the result of industry activities in support of OCS exploration, extraction, and production. An extensive upstream support infrastructure system exists to

support offshore oil and gas and includes platform fabrication yards, shipyards, repair and maintenance yards, onshore service bases, heliports, marinas for crewboats and supply boats, pipeline coating companies, and waste management facilities. Downstream infrastructure moves hydrocarbon product to market and includes gas processing plants, petrochemical plants, transportation corridors, petroleum bulk-storage facilities, and gas and petroleum pipelines. This infrastructure system is both widespread and concentrated. Much infrastructure is located in coastal Louisiana, less in coastal Texas, and less still in Mississippi's Jackson County and Alabama's Mobile County. While many fabrication and supply facilities are concentrated around coastal ports, downstream processing is concentrated more in industrial corridors farther inland (The Louis Berger Group, Inc., 2004).

This analysis identifies potential environmental justice impacts that might arise from these support activities, but they are only indirectly influenced by BOEMRE decisionmaking, and BOEMRE has no regulatory authority over them. Third, the resulting onshore support activities occur in the context of a very large and long-established oil industry. For the most part, activities generated by a new lease sale occur where there are ongoing ones, and the two are virtually indistinguishable from each other or from established land-use patterns. Each industry sector and its associated impacts are often cumulative and occur within a mix of the effects of other sectors in each geographic location. Several of BOEMRE's past and ongoing studies (e.g., Hemmerling and Colten, 2003 and in preparation) seek to understand the underlying socioeconomic and potential environmental justice implications of OCS activities. Several ongoing studies also seek to understand the short- and long-term impacts of the recent DWH event (e.g., the study "Ethnic Groups and Enclaves Affected by OCS," which was launched on August 1, 2010). The BOEMRE will continue to seek additional information and bases the following analysis on the best information currently available.

4.1.1.21.4.1. Description of the Affected Environment

A detailed description of environmental justice from the WPA and CPA can be found in Chapters 4.2.1.1.13.4 and 4.2.2.1.15.4 of the Multisale EIS. Additional information regarding the additional 181 South Area and any new information found since the publication of the Multisale EIS is presented in Chapter 4.1.16.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the resource description incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

The oil and gas exploration and production industry and its associated support sectors are interlinked and widely distributed along the Gulf Coast. Offshore OCS-related industry operations within the CPA may rely on onshore facilities within the CPA, WPA, or both. As an example, Port Fourchon in Lafourche Parish, Louisiana, caters to 90 percent of all deepwater oil production in the GOM and roughly 45 percent of all shallow-water rigs in the Gulf (Loren C. Scott & Associates, 2008). While this analysis focuses on potential impacts within the CPA, the interlinked nature of the offshore industry necessitates a discussion of the WPA as well. Within the GOM economic impact areas, there are 81 counties/parishes that contain facilities, with five as the median number of facilities. For comparative purposes, counties/parishes with more than five facilities are considered to contain concentrations of facilities. These 39 counties/parishes are then divided into three levels of infrastructure concentration: low (6-15 facilities); medium (16-49 facilities); and high (50 or more facilities). The WPA has four high concentration counties/parishes, and the CPA has six, five of which are located in Louisiana. Most of the counties/parishes with low and medium concentrations are located in Texas (WPA) or Louisiana (CPA).

The OCS activities (and their potential environmental consequences) are concentrated around support infrastructure such as ports, canals, heliports, repair yards, pipecoating facilities, and gas processing plants. While the coastal zone of the northern GOM is not a physically, culturally, or economically homogenous area, some communities within its boundaries warrant an environmental justice lens (Gramling, 1984b). The USEPA's guidelines suggest different thresholds for determining whether a community or local population should be considered an environmental justice population. The BOEMRE focuses on counties/parishes with high or medium concentration of OCS-related infrastructure and defines minority populations as those counties/parishes that exhibit ethnic characteristics that are above 50 percent of the total population.

Environmental justice maps (**Figures 4-15 through 4-18**) display the location of oil-related infrastructure and the distribution of low-income and minority residents across GOM counties and

parishes based on U.S. Census data from 2010 and a BOEMRE-funded study on Gulf Coast OCS infrastructure. Ten counties/parishes are considered to have a high concentration (50 facilities or more) of oil-related infrastructure (Table 3-40 of the Multisale EIS). Of these 10 counties/parishes, 6 are located in the CPA, and of those, 3 have higher minority percentages than their respective State averages: 41 percent minority residents are in Mobile County, Alabama; 44 percent minority residents are in Jefferson Parish, Louisiana; and 43 percent minority residents are in St. Mary Parish, Louisiana. Jefferson Parish, Louisiana, ranks second in terms of concentration of OCS-related infrastructure with 1 petrochemical plant, 46 terminals, 8 ship yards, and 6 platform fabrication facilities among other infrastructure types (Kaplan et al., in preparation). A BOEMRE-funded study, using the 2000 Census and a weighting scheme to identify counties with heavy concentrations of OCS infrastructure, identified a dozen areas within Jefferson Parish where African Americans make up more than 75 percent of the population. The analysis found a visual correlation between the concentration of black population and OCS-related infrastructure along the Harvey Canal.

Thirteen counties/parishes are considered to have a medium concentration (16-49 facilities) of oil-related infrastructure. Of these 13 counties/parishes, 10 are located in the CPA, and of those, 3 have higher minority populations than the State average: Hillsborough County in Florida and Orleans and St. James Parishes in Louisiana. The population of metro New Orleans declined 11 percent since 2000, 140,845 residents in Orleans Parish alone, largely reflecting the significant job losses associated with Hurricane Katrina and the recession. The percentage of black population fell from 67.3 percent to 60.2 percent.

Poverty is defined by the Office of Management and Budget's Statistical Policy Directive 14 and the U.S. Census using a set of money income thresholds that vary by family size and composition. The official poverty thresholds do not vary geographically, but they are updated for inflation using the Consumer Price Index (U.S. Census). This analysis uses the 2009 Community Survey on a county/parish level basis as a placeholder. Only one parish, St. Mary Parish, out of the six CPA high infrastructure concentration counties/parishes has a higher poverty rate than its respective State poverty rate, with 18 percent of the parish living below the poverty line compared with the State's 17.6 percent average. Four parishes (Iberia, Orleans, St. Bernard, and Vermilion) out of the 10 CPA medium infrastructure concentration counties/parishes had higher poverty rates than their respective State poverty rate. In the aforementioned Eastern Research Group study, which uses census tract data (a smaller level of geographic analysis), they found five areas in Jefferson Parish, Louisiana, where more than half the population had an income below the poverty level; this population is clustered in the northern part of the parish. In Orleans Parish, using 2000 data, there was not much visual correlation between areas of high poverty and OCS infrastructure, with the possible exception of one repair facility to the west of New Orleans.

Baseline Post Hurricanes and Post-*Deepwater Horizon* Event

Whether the proposed lease sale occurs within the CPA or WPA, oil and gas exploration and production activities would rely on an established network of support and processing facilities and associated labor force both within the onshore CPA and WPA. As a result, a baseline change within the WPA could potentially alter the relative risks of a lease sale in the CPA. Therefore, where appropriate, this discussion considers recent baseline changes in the WPA. On August 29, 2005, Hurricane Katrina made landfall on the Gulf Coast between New Orleans, Louisiana, and Mobile, Alabama. Hurricane Katrina had differential impacts on the Gulf Coast population. Approximately half of those displaced lived in New Orleans, Louisiana, where the storm heavily impacted the poor and African Americans (Gabe et. al., 2005). As stated in the Multisale EIS, the three states most affected also rank among the poorest according to the 2000 U.S. Census; Mississippi ranked second in its poverty rate, Louisiana third, and Alabama sixth. Approximately one-fifth (21%) of the population most directly affected by the storm was poor, a rate significantly higher than the national rate of 12.4 percent reported in the 2000 Census. While the 2008 hurricane season was particularly active in southeast Texas in the WPA, it also strongly affected CPA baseline conditions. Hurricane Gustav made landfall on September 1, 2008, near Cocodrie, Louisiana (Terrebonne Parish), and continued northwest across the state, resulting in 34 parish disaster declarations, which made areas eligible for disaster assistance following the storm (U.S. Dept. of Homeland Security, FEMA Emergency Declaration August, 2008). The affected coastal parishes also

have high concentrations oil-related infrastructure. Damage to Mississippi and Alabama coastal areas was less severe, but the National Weather Service reported 14 confirmed tornadoes from Biloxi to Mobile, Mississippi.

The DWH event on Mississippi Canyon Block 252 has raised several concerns regarding OCS activities and environmental justice. The Gulf Coast boasts several distinct ethnic, cultural, and low-income groups whose substantial reliance on the area's natural resources of the marshes, barrier islands, and coastal beaches and wetlands can make them particularly vulnerable to the direct and indirect effects of environmental impacts to coastal wetlands, marshes, barrier islands, and beaches. Besides an economic dependence on commercial fishing and oystering, coastal low-income and minority groups rely heavily on these fisheries and on other traditional subsistence fishing, hunting, trapping, and gathering activities, to augment their diets and household incomes (see Hemmerling and Colten, 2003, for an evaluation of environmental justice considerations for south Lafourche Parish). Even when landloss and destruction caused by recent hurricanes have forced families to relocate, regular commuting has sustained this reliance on the natural resources of the coastal environments. While by no means a complete inventory of the minority, ethnic, and nationality groups that make up this diverse region and that are engaged in natural resource use and/or the petroleum industry, several populations of note have been identified to underscore the potential for environmental justice concerns: African Americans, Cajuns, Chitimacha, Houma, Isleños, Laotians, Mexicans, and Vietnamese.

The DWH event and subsequent fishing closures dealt an immediate blow to many CPA coastal communities and may have longer term impacts by damaging fish stocks or by undermining the Gulf Coast seafood "brand." Members of several minority and low-income groups, including among others African Americans, Cajuns, Houma, and Vietnamese, rely on the commercial seafood industry. For example, an estimated 20,000 Vietnamese fishermen and shrimpers live along the Gulf Coast; by 1990, over 1 in 20 Louisiana fishers and shrimpers had roots in Southeast Asia even though they comprised less than half a percent of the State's workforce (Bankston and Zhou, 1996). As of Spring 2010, 30-50 percent of all commercial fishers living in the Gulf of Mexico region were Vietnamese Americans, while 80 percent of all Vietnamese Americans in the region were connected to the seafood industry (Mississippi Coalition of Vietnamese Fisherfolk and Families, 2010). African Americans, although not exclusively, have traditionally comprised much of the fish processing and oyster shucking industries, and shucking houses, particularly, have provided an avenue into the mainstream economy for minority groups (Brassieur et al., 2000). African Americans in lower Plaquemines Parish, where Pointe a la Hache and other black towns such as Davant and Phoenix are found, have worked and subsisted on the natural resources of the regions for generations (The Louisiana Justice Institute, 2010). A representative sample of affidavits submitted to the Gulf Coast Claims Facility (responsible for administrating DWH event claims) indicates that Louisiana commercial fisherfolks customarily take home approximately 5-15 percent of their total catch for subsistence use (United Louisiana Vietnamese American Fisherfolks, 2010).

Disruptions to the oil and gas industry because of the DWH event and the subsequent deepwater drilling suspensions have also raised equity concerns. The Multisale EIS states the following: "Evidence also suggests that a healthy offshore petroleum industry also indirectly benefits low-income and minority populations." Recent data from the U.S. Census confirms that a sizable workforce (a little over 17,000 workers) employed in mineral extraction live in the southeastern coastal parishes of Louisiana. One Agency study in Louisiana found income inequality decreased during the oil boom and increased with the decline (Tolbert, 1995). Prior to the DWH even, "certain rural coastal parishes [were home to] more jobs in their parishes than workers [residing there], implying that Louisianians in neighboring parishes rely on these areas for their employment" (Plyer and Campanella, 2010). Plaquemines Parish, for example, was home to close to 12,000 jobs, but only about 7,000 workers, and 11.5 percent of Terrebonne Parish's jobs were in the oil and gas industry. The long-term socioeconomic impact to low-income and minority communities because of industry uncertainty has the potential to reverberate across the region.

The DWH is one of three substantial crises experienced by Louisiana coastal communities during the last 6 years, and the environmental justice concerns from future events must be considered in this context. First, southeast Louisiana is losing coastal land from erosion and subsidence because of both natural processes (e.g., hurricanes) and human activities (e.g., control and diversion projects) (Morton, 2003). For example, since measurements began in 1956, 23 percent of the lands protecting the New Orleans metropolitan area from storm surges have converted to open water 1956 (Liu and Plyer, 2010). Besides

the decreased hurricane and oil-spill protections, rapid landloss and habitat fragmentation has impacted the ability to make a living, and flooding has even caused abandonment of whole communities. The second crises to impact the region includes the 2005/2008 hurricane season, consequences of which have been discussed above. While tropical weather is normal, low income and minority groups may bear a larger burden than the general population. An estimated 4,500 American Indians living on the southeast Louisiana coast lost their possessions to Hurricane Katrina according to State official and tribal leaders. Cajuns were also impacted by Katrina, and especially by Hurricane Rita, whose 20-ft (6-m) storm surges flooded low-lying communities in Cameron, Calcasieu, and other coastal parishes. Close to 90 percent of Louisiana Vietnamese live in seven southern parishes: Orleans, Jefferson, East Baton Rouge, St. Mary, Vermilion, Terrebonne, and Lafourche (Bankston and Zhou, 1996). The New Orleans East Vietnamese community of Village de L'Est was almost entirely flooded by levee failures following Hurricane Katrina. The third crises is the DWH event. Cumulatively, such events can reduce community resiliency and increase vulnerability to future hazards, opening them up to disproportionate affects from future catastrophic events.

Waste Management of the *Deepwater Horizon* Event Waste

The USEPA's standards exempt oil and gas exploration and production wastes from Federal hazardous waste regulations. This exemption does not preclude more stringent State and local regulation and USEPA recognizes that exploration and production wastes could present a human health hazard if not properly managed (USEPA, 2002). However, wastes from oil spills are not exempt, and the DWH event has raised the additional environmental justice concern as to whether or not low-income and minority groups have been disproportionately impacted by the disposal of wastes associated with the DWH event's containment and cleanup. Disposal procedures involved sorting waste materials into standard "waste stream types" at small, temporary stations and, then, sending each type to existing facilities that were licensed to dispose of them. The location of temporary sorting stations was linked to the location of containment and cleanup operations. Hence, future locations of any sorting stations would be determined by the needs of cleanup operations. However, waste disposal locations were determined by the specializations of existing facilities and by contractual relationships between them and the cleanup and containment firms. Although, in the case of the DWH event, most cleanup occurred in the CPA, but disposal occurred in both the CPA and WPA. The requirements of the cleanup operations would likely determine the use of facilities in both the CPA and WPA should a future event occur. **Tables 4-39 and 4-40** identify the DWH waste disposal sites that received the greatest percentages of waste and the waste types received. **Table 4-41** also shows minority and low-income percentages, as well as the density of populations living within 1 mi (1.6 km) of each site. **Figure 4-19** is a map that shows the location of all sites that received DWH waste. Argonne National Laboratory reported that there are 46 waste management facilities that service the oil and gas industry along the GOM, with 18 in Louisiana, 18 in Texas, 5 in Mississippi, 4 in Alabama, and 1 in Florida (Puder and Veil, 2006). Louisiana received about 82 percent of the DWH event's liquid waste recovered; of this, 56 percent was manifested to mud facilities located in Venice, Plaquemines Parish, Louisiana, and in Port Fourchon, Lafourche Parish, Louisiana; it was then transferred to a processing facility in Port Arthur, Texas. The waste remaining after processing was sent to deep well injection landfills located in Fannett and Big Hill, Texas. The sites located in Venice and Port Fourchon, Louisiana, and in Port Arthur, Fannett, and Big Hill, Texas, have low minority populations, but a few of these areas have substantial poverty rates relative to State and county means.

4.1.1.21.4.2. Impacts of Routine Events

Background/Introduction

A detailed analysis of the routine impacts of OCS activities on low-income and minority communities and environmental justice as a whole for the CPA proposed action can be found in Chapter 4.2.2.1.15.4 of the Multisale EIS and in Chapter 4.1.16.4.2 of the 2009-2012 Supplemental EIS, respectively. Impact analyses for the 181 South Area that include new information since publication of the Multisale EIS are presented in Chapter 4.1.16.4.1 of the 2009-2012 Supplemental EIS. **Chapter 4.1.1.21.4.1** describes the widespread presence of an extensive OCS support system and associated labor force, as well as economic

factors related to OCS activities. The following information is a summary of the impact analysis incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Impact-producing factors associated with the CPA proposed action that could affect environmental justice include the following: (1) potential infrastructure changes/expansions including (a) fabrication yards, (b) support bases, and (c) onshore disposal sites for offshore waste; (2) increased commuter and truck traffic; and (3) employment changes and immigration. Possible changes/expansions/increases to any of these routine impact-producing factors of OCS activities occur in the context of the long-lived State and Federal oil and gas leasing programs and as incremental additions to a robust offshore oil and gas industry. As a result, the impacts from routine events produced by the CPA proposed action due to these factors are also incremental. Particularly in the case of potential social impacts, it is often not possible to separate out each additional new OCS Program effect from ongoing impacts because dynamic economic and political factors can influence investment decisions that, one way or another, will reverberate through many of the OCS economic impact areas. While individual sales have little influence on the factors causing impacts from routine events, the overall OCS Program may have more. For this reason, the factors considered in this chapter are explored in more detail in the cumulative analysis **Chapter 4.1.1.21.4.4**. Offshore operations within the CPA may be supported by onshore facilities within the WPA. For example, Gulf Coast States have a dedicated industry-specific network of offsite commercial disposal companies and facilities. Therefore, waste produced from activities in the CPA brought onshore at Port Fourchon in Lafourche Parish, Louisiana, may be sent to processing facilities in Texas and finally sent to deep well injection landfills in Fannett or Big Hill Texas (Puder and Veil, 2006). Therefore, this analysis of possible impacts due to the CPA lease sale addresses potential impacts from the WPA as well. The BOEMRE estimates that production from the CPA proposed action would be 0.801-1.624 BBO and 3.332-6.560 Tcf of gas, which is a marginal decrease in production from the last lease sale.

Proposed Action Analysis

The Executive Order mandating an environmental justice analysis arose out of cases where minority and/or low-income communities disproportionately bore the environmental risk or direct burdens of industrial development or Federal actions. As discussed in **Chapter 4.1.1.21.4.1**, the OCS Program in the GOM is large and has been ongoing for more than 50 years. While the program is offshore, onshore activities related to it occur within a mix of communities whose economies are linked in various ways and at differing levels to its many industrial sectors.

Fabrication/shipbuilding yards and port facilities are major infrastructure types that demonstrate the interlinked nature of OCS activity within the GOM and pose potential environmental justice risks. As mentioned earlier, CPA oil and gas exploration and production help to maintain ancillary industries within the WPA, including waste processing facilities. Over one-third (28 facilities) of the U.S. major shipbuilding yards are located on the GOM. Of these, most facilities are concentrated in a 200-mi (322-km) area between New Orleans, Louisiana, and Mobile, Alabama. The offshore oil industry relies heavily on specialized port infrastructure that specifically serves the need of the industry. Such activities as repair and maintenance of supply vessels, fabrication yards, and supply bases tend to be located in ports nearest to offshore drilling operations. Thus, the 34 OCS-related service bases are mainly concentrated on the coast of Louisiana, with a handful located in Mississippi, Alabama, and Florida (The Louis Berger Group, Inc., 2004). Since the CPA proposed action would help to maintain ongoing levels of activity rather than expand them, it would not generate new infrastructure demand sufficient to raise siting issues. Also, prior to construction, any new OCS-related onshore facility would first be required to receive approval by relevant Federal, State, county and/or parish, and community governments with jurisdiction. The BOEMRE assumes that any new construction would be approved only if it were consistent with appropriate land-use plans, zoning regulations, and other State/regional/local regulatory mechanisms. For these reasons, this Supplemental EIS considers infrastructure projections only for the cumulative analysis (**Chapter 4.1.1.21.4.4**).

All material that moves to and from an offshore platform goes through an onshore service base. Although support and transport operations are spread throughout the Gulf Coast, most producing deepwater fields have service bases in southeast Louisiana and much of this goes through Port Fourchon

in Lafourche Parish, Louisiana. Port Fourchon has grown in recent decades, in large measure due to its role in servicing the deepwater OCS, and it is currently undergoing a 400-ac (162-ha) expansion. Indicating the growth of the port, port operating revenues with a 5 percent annual increase of the lease rental rate rose from $3.38 million in 1996 to $6.16 million in 2000 (Port Services 22).

LA Hwy 1 is the primary north-south corridor through Lafourche Parish and is the principal transportation route for trucks entering and exiting Port Fourchon. According to the LA 1 Coalition, a nonprofit corporation working to improve LA Hwy 1, between 1991 and 1996, there were over 5,000 accidents along this largely rural two-lane highway. According to some studies, LA Hwy 1's fatality rate is double that of similar highways (LA 1 Coalition, 2010a). Additionally, LA Hwy 1 is the only means of evacuation for thousands of people. Approximately 35,000 people, including 6,000 offshore workers, use LA Hwy 1 for hurricane evacuations (LA 1 Coalition, 2010a). According to one study, the average daily traffic along LA Hwy 1 appears to be heavily influenced by the overall level of oil and gas activities and due to increased demand, particularly for deepwater services (Guo et al., 1998). Residents along the highway have expressed concern over LA Hwy 1's adequacy for traffic congestion, desiring improved hurricane evacuation, and emergency medical transportation routes (USDOT, Federal Highway Administration, 2004).

While local governments near the service bases have gained revenue from the increased activity within their jurisdictions, the demands for additional services and facilities resulting from oil and gas operations have sometimes exceeded growth in the revenue stream. A Federal cost share helped support the construction of the Leeville Bridge in 2009, considered the weakest link of the LA Hwy 1 system; the two-lane Leeville overpass is expected to open to traffic in November 2011 (LA 1 Coalition, 2010b). A proposed 27.5 mi (44.3 km) of improvements to the Port Fourchon highway system have yet to be funded, and continued growth of Port Fourchon and associated road traffic would add to an increased risk for users of and residents along the highway. As described in **Chapter 4.1.1.21.4.1**, community string settlement patterns in the area (in this case, on high ground along LA Hwy 1 and Bayou Lafourche) mean that all income groups would be affected by any increased traffic alike. For considering environmental justice, the percentage of a group's population within an affected area is often compared with the percentage of that population for the state. Using this method, two minority populations are at greater risk. Hispanics are 1.36 times more likely to live along the transportation corridor, and Native Americans are twice as likely to live along the transportation corridor than anywhere else in the parish (Hemmerling and Colten, 2003). While the majority of OCS-related infrastructure in south Lafourche Parish is near where the Houma Indian population resides, the CPA proposed action would not significantly alter this preexisting situation. Over the last two decades, the area has been experiencing increased truck traffic and its associated effects due to increasing offshore-related activities at Port Fourchon. Since the CPA proposed action would significantly alter this preexisting situation, minority and low-income populations would not sustain disproportionate adverse effects from the proposed action.

The development of any new oilfield would result in an increase in hazardous materials transported onshore. An estimated 0.2-2.0 bbl of total drilling waste are produced for each vertical foot drilled (USEPA, 2000b, p. 37), although not all oilfield waste is considered hazardous material. The BOEMRE rules require that all waste considered hazardous be transported onshore and disposed of, which lowers the risks to the environment but increases the risk to those people living along the hazardous transportation routes (NTL 2009-G35, USDOI, MMS, 2009e). The USDOT currently recommends a default isolation distance of one-half mile around any roadway involved in a hazardous chemical fire. Argonne National Laboratory reported that there are 46 waste management facilities that service the oil and gas industry along the GOM, with 18 in Louisiana, 18 in Texas, 5 in Mississippi, 4 in Alabama, and 1 in Florida (Puder and Veil, 2006). Because a relatively small amount of waste results from a single sale and because of the difficulty of separating out the relative contribution of all OCS waste from municipal waste in general or distinguishing the effects on nearby communities of OCS waste disposal from the disposal of other waste, this Supplemental EIS addresses the marginal contribution of the CPA proposed action on waste issues as part of the cumulative analysis (**Chapter 4.1.1.21.4.4**). While most waste disposal facilities along the GOM suffered little reported damage during recent hurricane seasons, a discussion of potential impacts to these sites as a result of storms is addressed in the cumulative analysis as well.

Because of Louisiana's extensive oil-related support system (**Chapter 4.1.21.1**), that State is likely to experience more employment effects related to the CPA proposed action than are the other coastal states.

As has been the case with several prior lease sales, Lafourche Parish, Louisiana, is likely to experience the greatest concentration of these benefits. The BOEMRE employment projections can neither estimate the socioeconomic or ethnic composition of new employment nor identify the communities in which that employment would likely occur. Sectors such as the fabrication industry and support industries (e.g., trucking) employ minority workers and provide jobs across a wide range of pay levels and educational/skill requirements (Austin et al., 2002a and 2002b; Donato et al., 1998). Also, evidence suggests that a healthy offshore petroleum industry does indirectly benefit low-income and minority populations. For example, one Agency study in Louisiana found income inequality decreased during the 1970's oil boom and increased with the mid-1980's decline (Tolbert, 1995). Because of the expected concentration of employment effects in Lafourche Parish, it is also the only parish where the additional OCS-related activities and employment may be sufficient to increase stress to its infrastructure. For example, one study found that because of local labor shortages in the past, employers actively recruited foreign employees including Laotian refugees and Mexican migrant workers. This trend has, in turn, applied pressure on available housing stocks within some GOM coastal communities that exhibited varying degrees of results in incorporating new residents into local communities (Donato, 2004). However, these effects arose during a time of a booming economy and high employment in general. According to BOEMRE estimates, the CPA proposed action would provide little additional employment growth. Instead, it would have the effect of maintaining current activity and employment levels, which is expected to have beneficial, although limited, direct and indirect employment effects to low-income and minority populations.

While a reevaluation of the baseline conditions pertaining to environmental justice was recently conducted as a result of the recent DWH event, it is yet to be seen how issues like new industry regulations and long-term biological impacts of the spill will affect minority and low-income communities residing along the CPA coast.

Summary and Conclusion

Because of the existing extensive and widespread support system for OCS-related industry and associated labor force, the effects of the CPA proposed action are expected to be widely distributed and to have little impact. This is because the proposed action is not expected to significantly change most of the existing conditions, such as traffic or the amount of infrastructure. In general, who would be hired and where new infrastructure might be located is impossible to predict but, in any case, it would be very limited. Because of Louisiana's extensive oil-related support system, that State is likely to experience more employment effects related to the CPA proposed action than are the other coastal states, and because of the concentration of this system in Lafourche Parish, that parish is likely to experience the greatest benefits from employment benefits and burdens from traffic and infrastructure demand. Similarly, impacts related to the CPA proposed action are expected to be economic and to have a limited but positive effect on low-income and minority populations, particularly in Louisiana and Lafourche Parish. However, given the low levels of expected effects and given the existing distribution of the industry and the limited concentrations of minority and low-income peoples, the CPA proposed action is not expected to have a disproportionate effect on these populations even in Lafourche Parish.

The CPA proposed action is not expected to have disproportionate high/adverse environmental or health effects on minority or low-income people.

4.1.1.21.4.3. Impacts of Accidental Events

Impacts of accidental impacts on environmental justice for the CPA proposed action can be found in Chapter 4.4.14.4 of the Multisale EIS. Impact analyses for the 181 South Area that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.16.4.3 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analyses incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information available since both documents were prepared.

Proposed Action Analysis

Impact-producing factors associated with the CPA proposed action that could affect environmental justice include (1) oil spills, (2) vessel collisions, and (3) chemical/drilling-fluid spills. These factors could affect environmental justice through (1) direct exposure to oil, dispersants, degreasers, and other chemicals that can affect human health; (2) decreased access to natural resources due to environmental damages, fisheries closures, or wildlife contamination; and (3) proximity to onshore disposal sites used in support of oil and chemical spill cleanup efforts. The DWH event was an accidental event of catastrophic proportion and should be distinguished from accidental events that are smaller in scale and occur more frequently. Detailed analysis of a high-impact, low-probability catastrophic event such as the DWH event may be found in **Appendix B**. Actions occurring within the CPA may impact environmental justice within the WPA, and vise versa. Facilities located on the coasts of the CPA may provide support for offshore activities on the WPA, and vise versa. Oil and chemical spills on the CPA may be carried by winds and currents to the coasts of the WPA, and vise versa. As a result, a discussion of a potential accidental event within the CPA proposed action area addresses potential impacts of accidental events to environmental justice both in the CPA and the WPA.

Potential oil spills including surface spills and underwater well blowouts may be associated with exploration, production, or transportation phases of the CPA proposed action. Detailed risk analysis of offshore oil spills ≥ 1,000 bbl, ≤1,000 bbl, and coastal spills associated with the CPA proposed action is provided in Chapters 4.3.1.4, 4.3.1.6, and 4.3.1.7 of the Multisale EIS, respectively. When oil is spilled in offshore areas, much of the oil volatilizes or is dispersed by currents, so it has a low probability of contacting coastal areas. Low-income and minority populations might be more sensitive to oil spills in coastal waters than the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with purchased ones, and their likelihood of participating in cleanup efforts and other mitigating activities. **Table 3-7** contains the estimated number of oil spills that could happen in Gulf coastal waters as a result of an accidental event associated with the CPA proposed action.

Vessel collisions may be associated with exploration, production, or transportation activities that result from the CPA proposed action and are the most common source of OCS-related spills. Chapter 4.3.3 of the Multisale EIS provides a detailed discussion of vessel collisions. The BOEMRE data show that, from 1996 through 2005, there were 129 OCS-related collisions. The majority of vessel collisions involve service vessels colliding with platforms or pipeline risers, although sometimes vessels collide with each other. These collisions often result in spills of various substances, and while most occur on the OCS far from shore, collisions in coastal waters can have consequence to low-income and minority communities. For example, on July 23, 2008, a barge carrying heavy fuel collided with a tanker in the Mississippi River at New Orleans, Louisiana. Over several days the barge leaked an estimated 419,000 gallons of fuel. From New Orleans to the south, 85 mi (137 km) of the river were closed to all traffic while cleanup efforts were undertaken, causing a substantial backup of river traffic (USDOC, NOAA, 2008c). Downriver from the collision, cities and parishes that pull drinking water from the river (i.e., Gretna, Algiers, and St. Bernard and Plaquemines Parishes) shut their water intakes out of fear of possible treatment system contamination (Tuler et al., 2010). Not only can these types of events erode public confidence in governmental and corporate institutions, they may compromise municipal services for which low-income communities may be financially unable to find private market substitutions, interfere with people's ability to use natural resources, or even interfere with people's ability to travel to work, as in the case of this spill which temporarily shutdown ferry service between Algiers and downtown New Orleans. These types of events may impact an entire region, but low-income and/or minority groups lacking financial or social resources may be more sensitive and less equipped to cope with the disruption these events pose. While this event did not involve OCS-related transportation, it is an example of the types of impacts from an accidental spill that could have environmental justice consequences.

Chemical and drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Chapter 4.3.4 of the Multisale EIS provides a detailed discussion of chemical and drilling-fluid spills. Each year, between 5 and 15 chemical spills are expected to occur; most of these are ≤50 bbl in size. Large spills are much less frequent. For example, from 1964 to 2005, only two chemical spills of ≥1,000 bbl occurred. Dispersants are of particular

concern for human health because, while dispersants are a relatively common product used to clean and control oil spills, they can evaporate from fresh crude and weathered oil and can come ashore as a result of burning oil out at sea. While additional production chemicals are needed in deepwater operations where hydrate formation is a possibility, overall spill volumes are expected to remain stable because of advances in subsea processing.

With the exception of a catastrophic accidental event, such as the DWH event, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area. As described earlier, low-income and/or minority groups lacking financial or social resources may be more sensitive and less equipped to cope with the disruption these events pose over the short term, but again, these smaller events should not have disproportionate long-term affects on low-income and minority communities.

Deepwater Horizon *Event*

While it is still too early to determine the long-term social impacts that may result from the DWH event, anecdotal evidence from media coverage and phone survey studies suggest possible trends that may represent disproportionate effects to low-income and minority communities. The National Center for Disaster Preparedness at the Mailman School of Public Health at Columbia University, in partnership with the Children's Health Fund, conducted a phone study (through the Marist Poll) between July 19 and July 25, 2010, of 1,203 adult residents of Louisiana and Mississippi living within a 30-minute drive from the Gulf of Mexico (Abramson et al., 2010). Survey respondents earning less than $25,000 reported having lost income as a result of the DWH event, and they were more likely than were higher earners to report physical (defined as respiratory symptoms or skin irritations) and mental health effects among themselves and their children. Black respondents were also more likely to report physical health problems both for their children and themselves as a result of the DWH event (Abramson et al., 2010). In a study of communities near the *Exxon Valdez* spill, Palinkas et al. (1992) suggest that cultural differences played an important role in the perception of the psychological damage produced by the disaster, which was related to "the cleaning work in which the people were involved and also the damage to fishing grounds, the main sustenance of these communities" (Palinkas et al., 1992). This work underscores the importance of the varying capacities of affected groups to cope with these types of events.

The Gulf Coast Claims Facility (GCCF) Program, administered by the Federal Government's Claims Administrator Kenneth R. Feinberg, has provided data on DWH spill claimants divided by claim type, payout amount, and county/parish in which the claimant worked or originated from. The fund is the official way for individuals and businesses to file claims for costs and damages incurred as a result of the oil discharges due to the DWH event. While not organized by minority or income group, these data allow us to identify where claims are being made and to compare this with environmental justice communities of note. In **Table 4-42**, total GCCF Program claimants as of November 25, 2010, are divided by state and at what stage the claimant is within the claims process. A total of 450,711 claimants, including individuals and businesses (claimants may have one or more claim type) have filed for some kind of emergency or final payment. These claims include claims for removal and cleanup costs, real or personal property, lost earnings or profits, loss of subsistence use of natural resources, and physical injury/death directly or indirectly because of the DWH event (see **Table 4-42** for a state-by-state break down). Many of these coastal counties and parishes contain large metropolitan centers as well as beach communities with economies based at least partially on tourism and recreation. Claimants can range from charter boat operators working out of Florida to bartenders working in downtown New Orleans. Either the direct effects of the DWH event or the indirect effects caused by altered perception were grounds for claims, if loss could be demonstrated. These figures include claimants living within the county or parish where the claim was made, claimants claiming losses while working in the county or parish where the claim was made, or both. Because impacted industry may employ low-income or minority workers, this analysis considers both businesses and individuals within a parish or county because both could result in potential environmental justice consequences.

Claimants were from coastal counties/parishes; there is no observable relationship between low-income or high-minority communities and number of claims. **Figure 4-20** displays the distribution of the GCCF Program's claimants and the average amount paid to each claimant by county/parish. Several

high- or medium-OCS infrastructure counties/parishes of environmental justice concern had high numbers of residents, workers, or both claiming losses. In Mobile County, Alabama, the GCCF Program awarded 9,515 claimants a total of $144,886,265. In Florida, 189 claimants were awarded $2,540,400 in Miami-Dade County and 303 claimants were awarded $4,765,700 in Hillsborough County. In Louisiana, 22,320 claimants were awarded a total of $227,338,000 in Orleans Parish; 2,130 claimants were awarded a total $86,645,800 in Plaquemines Parish; 1,942 claimants were awarded $38,135,100 in St. Bernard Parish; and 1,821 claimants were awarded $47,459,000 in Lafourche Parish. Harrison County, Mississippi, which encompasses Biloxi and Gulfport and is home to a 33 percent minority population, had 8,252 claimants awarded $111,699,036.

Chapter 4.1.1.21.4.1. discusses the DWH event's waste disposal system. While there are concerns about whether locations would worsen existing environmental injustices, waste disposal locations were determined by the specializations of existing facilities and by the contractual relationships between them and cleanup and containment firms.

Subsistence

While users of coastal waters may trend towards the relatively affluent, because of the limited ability of low-income and minority subsistence users to acquire comparable substitutes for Gulf of Mexico natural resources, they may be particularly sensitive to an oil spill and related fishery closures. Several ethnic minority and low-income groups rely substantially on subsistence-based activities for food, shelter, clothing, medicine, or other minimum necessities of life (e.g., see Hemmerling and Colten, 2003, for an evaluation of environmental justice considerations for south Lafourche Parish). The DWH event and the resulting NOAA fishing closures interrupted access to these resources for weeks or months depending on the area. As of November 27, 2010, over 29,722 DWH emergency advance payments claims had been filed claiming loss of subsistence use of natural resources. Of these many claims, only five had been paid out at a total of $13,000 distributed among the five claimants. Louisiana had the lion's share of claimants with 16,554 individuals claiming loss of subsistence use of natural resources, followed by Mississippi with 6,299 claims, Alabama with 4,119 claims, and Florida with 2,473 claims. To qualify for emergency funds, claimants were asked to identify the specific natural resource that had been injured, destroyed, or lost as a result of the DWH event; to describe the actual subsistence use for the natural resource; and to describe to what extent the subsistence use was affected by the damaged or destroyed natural resource using documentation such as store and barter receipts showing the replacement costs claimed (Gulf Coast Claims Facility, 2010b). The GCCF Program told the New Orleans newspaper, *The Times-Picayune*, that a claimant needs to "show documentation on their heritage, their history, and their having lived off the land" (Alexander-Bloch, 2010). In the Vietnamese fishing communities of Louisiana, however, these requirements have proven vague and challenging. Fishers save anywhere from 5 to 25 percent of their catch that they do not sell at the dock to feed themselves and immediate and extended family members or friends, and to contribute to community gatherings, such as weddings, church functions, local festivals, or to barter for other seafood, fruit, or vegetables (Alexander-Bloch, 2010). The BOEMRE is currently proposing a subsistence study of the Gulf Coast to better document subsistence distribution networks.

Health

Prior research on the health effects of oil spills have focused primarily on the acute physical symptoms of cleanup workers and wildlife caretakers. Of the 38 accidents involving supertankers and resulting in large oil spills throughout the world, only seven studies on the repercussions of the exposure of spilled oils on human health have been completed. Aguilera et al. (2010) compiled and reviewed these studies for patterns of health effects and found evidence of the relationship between exposure and "acute physical, psychological, genotoxic, and endocrine effects in the exposed individuals." Acute symptoms from exposure to oil, dispersants, and degreasers include headaches, nausea, vomiting, diarrhea, sore eyes, runny nose, sore throat, cough, nose bleeds, rash, blisters, shortness of breath, and dizziness (Sathiakumar, 2010). Sathiakumar also compiled and reviewed most of post-oil spill health studies and found that hydrocarbons were below occupational safety levels and that the level of benzene did not exceed threshold limit values. There has been concern regarding the use of the dispersant *Corexit 952*, which according to the New Jersey Department of Health, "may be absorbed through the skin; [and] should be handled as a carcinogen…[because it] can irritate the nose and throat; can cause nausea,

vomiting; diarrhea and abdominal pain, can cause headache, dizziness, lightheadedness, and passing out and may damage the liver and kidneys" (Trapido, 2010). The USEPA monitoring data has so far shown that the use of dispersants during the DWH event did not result in a presence of chemicals that surpassed human health benchmarks (Trapido, 2010). Studies of possible long-term health effects from exposure to either the DWH event's oil or dispersants, such as the possible bioaccumulation of toxins in tissues and organs, are lacking and the potential for the long-term human health effects are largely unknown (although the National Institutes of Health has proposed such a study). Sathiakumar also suggests long-term studies to clarify potential genotoxic and endocrine changes.

As of November 27, 2010, the GCCF Program has received 8,638 claims for emergency advance payment for physical injury/death. Of those, 18 have been paid at a total of $14,336.50. As of the end of September 2010, U.S. poison control centers had taken 1,172 exposure calls involving physical exposure to an oil-spill-related toxin (e.g., oil, dispersant, food contamination, or other associated toxin) and 681 information calls from persons with questions about the medical impact of the DWH event. Most calls originated from the Gulf States and most exposures had come via inhalation, although some were through dermal exposure. The most common symptoms included headaches, nausea, vomiting, diarrhea, throat irritation, eye pain, coughing/choking, and dizziness (Trapido, 2010). Sathiakumar's review also found that, in prior post-spill cleanup efforts, the duration of cleaning work was a risk factor for acute toxic symptoms and that seamen had the highest occurrence of toxic symptoms compared with volunteers or paid workers. Therefore, participants in the DWH "Vessels of Opportunity" program, which recruited local boat owners (including Cajun, Houma Indian, and Vietnamese fishermen) to assist in cleanup efforts, would likely be one of the most exposed groups. African Americans are thought to have made up a high percentage of the cleanup workforce. The OSHA released two matrices of gear requirements for onshore and offshore Gulf operations that are organized by task (OSHA). Of past oil-spill workers, uninformed and poorly informed workers were at more risk of exposure and symptoms, demonstrating the importance of education and proper training of workers (Sathiakumar, 2010). One of the most serious health hazards reported was heat; about 740 heat-related events (i.e., illnesses) were reported for workers involved in cleanup (U.S. Dept. of Labor, OSHA, 2010).

The National Oceanic and Atmospheric Administration, the Food and Drug Administration, and State regulators have coordinated efforts to help prevent oil-tainted seafood from reaching the market. An assumption of the Food and Drug Administration's guidelines, however, is that people eat two meals of fish and one meal of shrimp per week, with no more than 3 ounces of shrimp per meal (approximately 4 jumbo shrimp). A Natural Resources Defense Council online survey of 547 Gulf Coast residents in Louisiana, Mississippi, Alabama, and Florida was conducted from August through October 2010 to assess seafood consumption rates in the Gulf coastal zone. Online survey tools generally suffer from an unknown level of selection bias; however, these numbers still provide at least a snapshot of local seafood consumption patterns, particularly for minority subsistence-reliant groups. The Asian/Pacific Islander ethnic group surveyed had an average fish consumption frequency of 5 times per week and median fish consumption frequency of 2 times per week, with some individuals reporting to eat fish 5-8 times per week (Natural Resources Defense Council, 2010). Native Americans and Asian/Pacific Islanders consumed oysters more frequently as well. The Asian ethnic group surveyed also had an average and median crab consumption frequency of 1 time per week and some respondents reporting to consuming crab 4 times per week. The Natural Resources Defense Council calculated total daily consumption rates in grams(g)/day for all respondents and found that the median daily consumption for the study as a whole was 48g/day, respondents from Louisiana rural coastal communities was 53.3g/day, and respondents from Vietnamese-American communities in Louisiana and Mississippi was 64g/day. All consumption rates exceeded the Food and Drug Administration's assumptions. In Gulf coastal areas, low-income and minority groups are heavy subsistence users of local seafood. The concern is that heavy subsistence users face higher than expected, and potentially harmful, exposure rates to PAH's from the DWH event. In a study following the *MV Erika* spill off the coast of France, rats were fed oil-contaminated mussels daily for 2 and 4 weeks. No evidence of genotoxicity was observed in the blood samples, although significant increases in DNA damage were observed in the liver and the bone marrow of the rats. The intensity of the DNA damage increased with the PAH contamination level of the mussels (Aguilera, 2010). Actual levels of exposure are unknown as are the potential health effects from higher than expected exposure, but State and local health monitoring and Federal health studies are either ongoing or in the proposal phase (Mackar, 2010).

Summary and Conclusion

Chemical and drilling-fluid spills may be associated with exploration, production, or transportation activities that result from the CPA proposed action. Low-income and minority populations might be more sensitive to oil spills in coastal waters than is the general population because of their dietary reliance on wild coastal resources, their reliance on these resources for other subsistence purposes such as sharing and bartering, their limited flexibility in substituting wild resources with purchased ones, and their likelihood of participating in cleanup efforts and other mitigating activities. With the exception of a catastrophic accidental event, such as the DWH event, the impacts of oil spills, vessel collisions, and chemical/drilling fluid spills are not likely to be of sufficient duration to have adverse and disproportionate long-term effects for low-income and minority communities in the analysis area.

An event like the DWH event could have adverse and disproportionate effects for low-income and minority communities in the analysis area. Many of the long-term impacts of the DWH event to low-income and minority communities are unknown. While economic impacts have been partially mitigated by employers retaining employees for delayed maintenance or through the GCCF Program's emergency funds, the physical and mental health effects to both children and adults within these communities could potentially unfold for many years. As studies of past oil spills have highlighted, different cultural groups can possess varying capacities to cope with these types of events (Palinkas et al., 1992). Likewise, some low-income and/or minority groups may be more reliant on natural resources and/or less equipped to substitute contaminated or inaccessible natural resources with private market offerings. Because lower-income and/or minority communities may live near and directly involved with spill cleanup efforts, the vectors of exposure can be higher for them than for the general population, increasing the potential risks of long-term health affects. To date, there have been no studies of possible long-term health effects for oil-spill cleanup workers. The post-DWH event human environment remains dynamic, and BOEMRE will continue to monitor these populations over time and to document short- and long-term DWH event impacts. In the future, the long-term impacts of the DWH event will be clearer as time allows the production of peer-reviewed research and targeted studies that determine those impacts.

The DWH event was a low-probability, high-impact catastrophic event. For the reasons set forth in the analysis above, the kinds of accidental events (smaller, shorter time scale) that are likely to result from the CPA proposed action may affect low-income and/or minority more than the general population, at least in the shorter term. These higher risk groups may lack the financial or social resources and may be more sensitive and less equipped to cope with the disruption these events pose. These smaller events, however, are not likely to significantly affect minority and low-income communities in the long term.

4.1.1.21.4.4. Cumulative Impacts

An impact analysis for cumulative impacts in the CPA and WPA on environmental justice can be found in Chapter 4.5.15.4 of the Multisale EIS. Impact analyses for the CPA and WPA that includes any new information since publication of the Multisale EIS is presented in Chapter 4.1.16.4.4 of the 2009-2012 Supplemental EIS. The following information is a summary of the impact analysis incorporated from the Multisale EIS and the 2009-2012 Supplemental EIS, and new information that has become available since both documents were prepared.

Background/Introduction

Of all activities in the cumulative scenario, those that could potentially impact environmental justice in the CPA include (1) proposed actions and the OCS Program, (2) State oil and gas activity, (3) existing infrastructure associated with petrochemical processing including refineries and polyvinyl plants, (4) existing waste facilities including landfill, (5) coastal erosion/subsidence, (6) hurricanes, (7) global climate change, and (8) the lingering impacts of the DWH event. The context in which people may find themselves, and how that context affects their ability to respond to an additional change in the socioeconomic or physical environment, is the heart of an environmental justice analysis. The OCS Program in the GOM is large and has been ongoing for more than 50 years with established infrastructure, resources, and labor pools to accommodate it. That said, low-income and/or minority groups lacking financial, social, or environmental resources or practical alternatives may be more sensitive to, or are less equipped than are other groups to cope with an consequences of an oil spill, such as interruptions to

municipal services or fisheries closures. In studies on social disaster resiliency, variables such as income inequality can negatively impact a community's ability to respond and recover from a disaster (Norris et al., 2008). Groups may be even less so equipped to respond to these types of events if, for example, they are already in the process of recovering from a hurricane. On the other hand, Cutter et al. (2008) found that previous disaster experience, defined as the number of paid disaster declarations, positively affected disaster resilience. This cumulative impact analysis examines how incremental additions to an established program from the CPA proposed action area potentially may interact with other ongoing impacts along the Gulf Coast. As explained in prior sections, the interlinked nature of the OCS industry requires a discussion of potential impacts both in the CPA and the WPA.

OCS Program

The CPA proposed action and the OCS Program have the potential to adversely impact low-income, minority, and other environmental justice communities either directly or indirectly from onshore activities conducted in support of OCS exploration, development, and production (for a fuller discussion on potential impacts from routine events and accidental events, see **Chapters 4.1.1.21.4.2 and 4.1.1.21.4.3**, respectively). Potential vectors for impacts include increases in onshore activity (such as employment, migration, commuter traffic, and truck traffic), additions to the infrastructure supporting this activity (such as fabrication yards, supply ports, and onshore disposal sites for offshore waste), and additional accidental events such as oil or chemical spills. The BOEMRE estimates that production from the CPA proposed action would be 0.801-1.624 BBO and 3.332-6.560 Tcf of gas and that production in both the CPA and WPA proposed actions would range from 28.562 to 32.57 BBO and 142.366-162.722 Tcf of gas during 2007-2046 (**Table 3-1**). **Chapter 3.3.1** describes the widespread and extensive OCS-support system and associated labor force, as well as economic factors related to OCS activities. The widespread nature of the OCS-related infrastructure serves to limit the magnitude of effects that a single proposed action or the overall OCS Program may have on a particular community. Future lease sales would serve mostly to maintain the ongoing activity levels associated with the current OCS Program.

For most of the Gulf Coast, the OCS Program will result in only minor economic changes. Generally, effects will be widely yet thinly distributed across the Gulf Coast and will consist of slight increases in employment and few, if any, increases in population. Some places could experience elevated employment, population, infrastructure, and/or traffic effects because of local concentrations of fabrication and supply operations. Because of Louisiana's extensive oil-related support system, that State is likely to experience more employment effects related to the CPA proposed action than are the other coastal states. Because Lafourche Parish, Louisiana, already services about 90 percent of all deepwater and 45 percent of all shallow-water oil and gas production in the Gulf, it is likely to continue experiencing benefits from the OCS Program (Loren C. Scott & Associates, 2008). While the addition of the C-Port in Galveston, Texas, is expected to increase Texas's share of future effects, Louisiana is likely to continue to experience more than do other Gulf Coast States. Except in Louisiana, the OCS Program is expected to provide little additional employment, although it will serve to maintain current activity levels, which is expected to be beneficial to Gulf region low-income and minority populations generally. The Multisale EIS states the following: "Evidence also suggests that a healthy offshore petroleum industry also indirectly benefits low-income and minority populations." One Agency study found income inequality in Louisiana decreased during the oil boom and increased with the decline (Tolbert, 1995).

Environmental justice often concerns infrastructure siting, which may have disproportionate and negative effects on minority and low-income populations. Since OCS lease sales help maintain ongoing levels of activity rather than expand them, no one sale generates significant new infrastructure demand. Pipeline shore facilities are small structures, such as oil metering stations, associated with pipeline landfalls. At present, there are 126 OCS-related pipeline landfalls and 50 OCS-related pipeline shore facilities in the GOM region (Table 3-38 of the Multisale EIS). Cumulatively, over the next 40 years, the OCS Program is expected to result in 32-47 new pipeline landfalls, and 4-6 pipeline shore facilities are projected (Table 4-9 of the Multisale EIS). From 25 to 36 landfalls are projected for Louisiana, 6-8 are projected for Texas, 1-3 are projected for Mississippi and Alabama, and 0 are projected for Florida. From 3 to 5 pipeline shore facilities are projected for Louisiana, 1-2 for Texas, 0-1 for Mississippi and Alabama, and 0 for Florida. Each OCS-related facility that may be constructed onshore must receive approval by the relevant Federal, State, and local agencies. Each onshore pipeline must obtain similar

permit approval and concurrence. The BOEMRE assumes that all such approvals would be consistent with appropriate land-use plans, zoning regulations, and other Federal/State/regional/local regulatory mechanisms. Should a conflict occur, BOEMRE assumes that approval would not be granted or that appropriate mitigating measures would be enforced by the responsible political entities.

As stated in **Chapter 4.1.1.21.4.1** the region as a whole is not homogenous, but there are several potentially vulnerable ethnic and socioeconomic groups, some residing in enclaves, dispersed throughout OCS Gulf of Mexico economic impact areas. It shows that the 10 counties/parishes with high concentrations of oil-related infrastructure (Table 3-40 of the Multisale EIS) are not generally those with high concentrations of minority and low-income populations and that, in these counties/parishes, many of the low-income and minority populations reside in large urban areas where the complexity and dynamism of the economy and labor force preclude measurable sale-level or programmatic-level OCS effects.

Two local infrastructure issues analyzed in **Chapter 4.1.1.21.4.1** could possibly have related environmental justice concerns: traffic on LA Hwy 1 and the Port Fourchon expansion. This analysis concludes that the minority and low-income populations of Lafourche Parish will share the negative impacts of the OCS Program with the rest of the population. However, most effects are expected to be economic and positive. It is likely that a proposed 27.5 mi (44.3 km) of improvements to the Port Fourchon highway system will be funded in the next few years, alleviating many of the associated issues with the highway.

While there is a link between a healthy oil industry and indirect economic benefits to all sectors of society, this link may be weak in some communities and strong in others, such as Lafourche Parish, Louisiana (Hughes et al., 2001). Even in these areas, the petroleum industry has not been a critical factor in social change, except for limited periods of time (Wallace et al., 2001). This is the conclusion of this Agency's 5-Year Programmatic EIS (USDOI, MMS, 2001b), which analyzed the contribution of the OCS Program in the GOM (i.e., its cumulative effects) to the cumulative factors affecting environmental justice. Impacts, including how communities respond to fluctuations in industry activity, vary from one coastal community to the next. Expansion or contraction of offshore or onshore oil and gas activity has produced moderate impacts in some communities, whereas other communities have dealt with episodes of rapid industry change with negligible to minor impact. Furthermore, non-OCS activities, such as expansions of the tourism industry or the highway system, often can generate socioeconomic impacts by being a catalyst for such things as in-migration, demographic shifts, population change, job creation and cessation, community development strategies, and overall changes in social institutions (i.e., family, government, politics, education, and religion). Reflecting this Agency's earlier 5-Year Programmatic EIS analysis, this analysis concludes that the contribution of the CPA proposed action to the OCS Program's cumulative environmental justice impacts would be negligible. The analysis also concludes that, overall, OCS programmatic impacts to environmental justice over the next 40 years would likely represent a very small proportion of the cumulative impacts of all activities that affect environmental justice.

State Oil and Gas

State oil and gas activity has the potential to adversely impact low-income, minority, and other environmental justice communities either directly or indirectly from onshore activities conducted in support of State oil and gas exploration, development, and production. Louisiana, Mississippi, and Alabama jurisdiction over mineral resources extends 3 nmi from the shore; Texas and Florida jurisdiction over the seabed extends out 9 nmi. The annual gas production from Alabama State waters has ranged from 150 to 200 Bcf or approximately 50 percent of the State's total gas production (State of Alabama, n.d.). While offshore leasing in shallow waters is in general decline, states like Louisiana are attempting to incentivize increased activity closer to the shore. In 2006, the Louisiana Legislature authorized the Louisiana Dept. of Environmental Quality to implement an Expedited Permit Processing Program, which has so far resulted in a 55 percent reduction in coastal permitting time (Louisiana Dept. of Natural Resources, 2009). In November 2010, Louisiana voters passed the Louisiana Natural Resource Severance Tax Amendment, which effectively decreases the amount of taxes retained by the State on the severance of natural resources, but it increases what can be collected by the parishes where resources are extracted (State of Louisiana, 2010). Whether this measure will increase individual parishes' incentive to encourage production closer to the coast is still unknown.

State offshore oil and gas programs pose the same potential issues as does the OCS Program, although since State leases are closer to land, their petroleum-related activities are generally viewed as having greater potential for directly impacting coastal communities. The BOEMRE assumes that sitings of any future facilities associated with State programs would be based on the same economic, logistical, zoning, and permitting considerations that determined past sitings. Revenues from State water oil programs have produced several positive impacts and the steady stream of oil exploration and development have produced positive cumulative impacts that include increased funding for infrastructure, higher incomes (that can be used to purchase better equipment for subsistence), better health care, and improved educational facilities. While industrialization generally leads to a shift in community organization and cultural development, the offshore oil and gas industry and its concentrated work schedule has been more accommodating of "traditional" activities, such as trapping and fishing, during their time at home (Luton and Cluck, 2003).

Downstream Activities

Existing infrastructure associated with petrochemical processing including refineries and the production of petroleum-based goods such as polyvinyl plants poses potential health and other related risks to minority and low-income communities. The BOEMRE projects that, cumulatively, 14 new gas processing plants would be needed in support of the OCS Program over the next 40 years. The marginal contribution of the CPA proposed action does not change the estimate. The geographic distribution of projected gas processing plants differs markedly from the current distribution. Three new gas processing plants are projected for Louisiana, which currently has 28; 2 are projected for Texas, which currently has 1; and 9 are projected for Mississippi and Alabama, which currently have 6. As described in **Chapter 3.3.5.8**, this distribution is based on economic and logistical considerations unrelated to the distribution of concentrations of minority or low-income populations. The BOEMRE cannot predict and does not regulate the siting of future gas processing plants. The BOEMRE assumes that sitings of any future facilities would be based on the same economic, logistical, zoning, and permitting considerations that determined past sitings and that they would not disproportionately affect minority and low-income populations. An environmental justice study of industrial siting patterns in Jefferson, St. Bernard, and Lafourche Parishes, Louisiana, found that "people appear to be moving into densely populated, largely industrial areas where the costs of rent are lower. In addition, people tend to be moving into newer housing" (Hemmerling and Colten, in preparation). This historical analysis revealed little evidence of systematic environmental injustice of various oil-related industries, with the demographic makeup of the communities changing after facilities arrived. Communities with a higher than average number of chemical plants should be monitored to ensure that industry dominating the landscape does not disproportionately burden low-income or minority communities.

Waste

Existing waste facilities, including landfills and oil waste pits, can pose potential environmental justice impacts to low-income and minority communities. The development of any new oilfield would result in an increase in hazardous materials transported onshore. **Tables 4-39 and 4-40** identify the DWH waste disposal sites that received the greatest percentages of waste and the waste types received. **Figure 4-19** shows the location of all sites that received DWH waste. Argonne National Laboratory reported that there are 46 waste management facilities that service the oil and gas industry along the GOM, with 18 in Louisiana, 18 in Texas, 5 in Mississippi, 4 in Alabama, and 1 in Florida (Puder and Veil, 2006). Because of existing capacity, no new waste disposal sites are projected for the cumulative case (The Louis Berger Group, Inc., 2004).

Coastal Erosion and Subsidence

Coastal erosion and subsidence in some parts of the southeastern coastal plain serves to amplify the vulnerability of communities, infrastructure, and natural resources to storm-surge flooding (Dalton and Jones, 2010). Submergence in the Gulf is occurring most rapidly along the Louisiana coast and more slowly in other coastal states. Depending on local geologic conditions, the subsidence rate varies across coastal Louisiana from 3 to over 10 mm/yr (0.12 to over 0.39 in/yr). Natural drainage patterns along

many Texas coast areas have been severely altered by construction of the Gulf Intracoastal Waterway and other channelization projects associated with its development. Saltwater intrusion resulting from river channelization and canal dredging is a major cause of coastal habitat deterioration (Tiner, 1984; National Wetlands Inventory Group, 1985; Cox et al., 1997); see **Chapter 4.1.1.4** for a discussion of wetlands in the CPA. As discussed in **Chapter 4.1.1.21.4**, tropical storms are the norm in the region, but low-income and minority communities may bear a larger burden than the general populations. Native Americans, Vietnamese, Cajun, African American, and other ethnic enclaves have all borne catastrophic losses in recent storm events. An estimated 4,500 Native Americans living on the southeast Louisiana coast lost their possessions to Hurricane Katrina according to State official and tribal leaders. Cajuns were also impacted by Hurricane Katrina, and especially by Hurricane Rita, whose 20-ft (6-m) storm surges flooded low-lying communities in Cameron, Calcasieu, and other coastal parishes. According to a USGS 5-year, post-Katrina survey, wetland loss from all four storms (Hurricanes Katrina, Rita, Gustav, and Ike) totaled 340 mi^2 (881 km^2).

Recent climate change projections suggest global sea level will rise by 0.8-2.0 m (2.6-6.6 ft) by 2100 due to climate change (Bryan et al., 2001; Kont et al., 2003; Overpeck et al., 2006; Pfeffer et al., 2008). Such a rise in sea level would cause unprotected shorelines to migrate inland and future hurricane storm-surge inundation to extend farther inland than contemporary hazard zones predict (Frazier et al., 2010). **Chapter 4.1.1.4** explains that disappearing dune and barrier island elevations and associated marshes make inland coasts more vulnerable to future hurricanes and wind-driven tidal or storm events. Several studies highlight the potentially disastrous effects of future hurricane storm-surge enhanced by sea-level rise on coastal communities (Cohen et al., 1997; Gommes et al., 1998; Field et al., 2001; Wu et al., 2002; Kleinosky et al., 2007). Even if hurricanes do not increase in frequency or intensity in the future, continued sea-level rise puts low-lying coastlines at much greater storm-surge risk (Frazier et al., 2010). Such sea-level rise increases the amount of people impacted by storm events and could also displace communities in areas below or near sea level.

Coastal subsidence and erosion can increase community vulnerability to future hazards and also threaten traditional ways of life. Saltwater intrusion reduces productivity and species diversity associated with Louisiana and Texas wetlands and coastal marshes (Stutzenbaker and Weller, 1989; Cox et al., 1997). While users of coastal waters may trend towards the relatively affluent, low-income and minority groups may be more dependent on the resources of the Gulf Coast. Several ethnic minority and low-income groups rely substantially on these resources for food, shelter, clothing, medicine, or other minimum necessities of life (e.g., see Hemmerling and Colten, 2003, for an evaluation of environmental justice considerations for south Lafourche Parish).

Coastal Storms

Hurricanes, tropical storms, and other wind-driven tidal or storm events are a fact of life for communities living along the Gulf of Mexico coastal zone. For low-income and minority populations, however, the impacts of coastal storm events can be particularly profound because of factors like limited resources to evacuate or to mitigate hazards. Baseline conditions pertaining to environmental justice were reevaluated in light of recent hurricane activity in the GOM. The intensity and frequency of hurricanes in the Gulf over the last 6 years has greatly impacted the system of protective barrier islands, beaches, and dunes and associated wetlands along the Gulf Coast. Within the last 6 years, the Gulf Coast of Texas, Louisiana, Mississippi, Alabama, and to some degree Florida have experienced five major hurricanes (Ivan, Katrina, Rita, Gustav, and Ike). Impacts from future hurricanes and tropical storm events are uncertain. Municipal programs like the New Orleans Office of Homeland Security and Public Safety’s City Assisted Evacuation Plan are being implemented to help citizens who want to evacuate during an emergency but lack the capability to self-evacuate (City of New Orleans, n.d.). Hazard mitigation funds available through individual states and FEMA also seek to mitigate potential damage to homes in flood zones throughout the Gulf. While hurricanes and tropical storms are inevitable, lessons learned from Hurricanes Katrina and Rita are shaping local and national policies as well as efforts by non-governmental organizations to protect low-income, minority, and other vulnerable communities.

Global Climate Change

While predictions remain uncertain, global climate change has the potential to adversely impact low-income and minority communities living within the Gulf of Mexico economic impact zones. Although research on the frequency and intensity of future hurricanes is still under debate (Shepherd and Knutson, 2007), consensus is emerging that climate change may result in fewer tropical cyclones but with increasing intensities and precipitation totals (Bengtsson et al., 2007; Edwards, 2008; Landsea et al., 2006). A regional model of the tropical North Atlantic used by the latest report from the Intergovernmental Panel on Climate Change found decreasing storm activity over the North Atlantic. A new technique for deriving hurricane climatologies from global data, applied to climate models, indicates that global climate change should reduce the global frequency of hurricanes, although their intensity may increase in some locations (Intergovernmental Panel on Climate Change, 2007b). Hurricane intensity has been demonstrated to be highly correlated to thermodynamic potential (warmer waters); therefore, it is believed that an increase in sea temperatures should lead to an amplification of storm intensity and increased rainfall totals (Emanuel, 2000 and 2005; Knutson and Tuleya, 2004; Pielke et al., 2005; Webster et al., 2005). Coupled with potential sea-level rise, global climate change exposes a greater number of the residential population and assets (i.e., infrastructure and natural resources) to the impacts of storms.

Deepwater Horizon *Event*

While it is still too soon to determine the long-term social impacts of the DWH event, anecdotal evidence from media coverage and early survey studies suggest the possibility of trends that might disproportionately affect low-income and minority communities for some time to come. A phone survey conducted by a team of LSU sociologists found that nearly 60 percent of the 925 coastal Louisiana residents interviewed reported being almost constantly worried by the DWH event (Lee and Blanchard, 2010). Studies of residents near past oil spills (such as the *Exxon Valdez* in Prince William Sound, Alaska) have noted impacts to social cohesion and increased distrust in government and other institutions, which contributed to community anxiety (Tuler et al., 2009).

Cumulative effects on social organization could include decreasing importance of family, cooperation, sharing, and subsistence availability. Long-term effects on wild resource harvest patterns might also be expected. While acute health effects from oil-spill events have been somewhat studied, the long-term impacts form exposure is unknown (Aguilera et al., 2010; Meo, 2009; Morita et al., 1999; Sathiakumar, 2010). Studies of possible long-term health effects from exposure to either the DWH event's oil or dispersants, such as the possible bioaccumulation of toxins in tissues and organs, are lacking, and the potential for the long-term human health effects are largely unknown (although the National Institutes of Health has proposed such a study). In prior post-spill cleanup efforts, the duration of cleaning work was a risk factor for acute toxic symptoms, and seamen had the highest occurrence of toxic symptoms compared with volunteers or paid workers (Sathiakumar, 2010). Therefore, participants in the DWH "Vessels of Opportunity" program, which recruited local boat owners (including Cajun, Houma Indian, and Vietnamese fishermen) to assist in cleanup efforts, would likely be one of the most exposed groups. African Americans are thought to have made up a high percentage of the cleanup workforce. In Gulf coastal areas, low-income and minority groups are heavy subsistence users of local seafood. The concern is that heavy subsistence users face higher than expected, and potentially harmful, exposure rates to PAH's from the DWH event. As mentioned earlier, the National Institutes of Health's proposed study should provide a better understanding of the long-term and cumulative health impacts, such as the consequences of working close to a spill and of consuming contaminated seafood. Several ongoing studies also seek to understand the short- and long-term impacts of the recent DWH event (e.g., the study "Ethnic Groups and Enclaves Affected by OCS," which was launched August 1, 2010). The BOEMRE will continue to seek additional information.

Summary and Conclusion

The cumulative impacts of the CPA proposed action would occur within the context of other impact-producing factors on environmental justice, including (1) proposed actions and the OCS Program, (2) State oil and gas activity, (3) existing infrastructure associated with petrochemical processing including

refineries and polyvinyl plants, (4) existing waste facilities including landfill, (5) coastal erosion/subsidence, (6) hurricanes, (7) global climate change, and (8) the lingering impacts of the DWH event.

Because of the presence of an extensive and widespread support system for the OCS and associated labor force, the effects of the cumulative case are expected to be widely distributed and, except in Louisiana, little felt. In general, the cumulative effects of the OCS Program are expected to be economic and to have a limited but positive effect on low-income and minority populations. In Louisiana, these positive economic effects are expected to be greater. In general, who would be hired and where new infrastructure might be located is impossible to predict, although a new C-Port in Galveston, Texas, is likely to increase Texas' share of effects. Given the existing distribution of the OCS-related industry and the limited concentrations of minority and low-income peoples, the cumulative OCS Program would not have a disproportionate effect on these populations. Lafourche Parish would experience the most concentrated effects of cumulative impacts. Because the parish is not heavily low-income or minority and because the effects of road traffic and port expansion would not occur in areas of low-income or minority concentration, these groups are not expected to be differentially affected.

To summarize, the CPA proposed action is not expected to have disproportionate high/adverse environmental or health effects on minority or low-income people, and in the GOM coastal area, the contribution of the proposed action and the OCS Program to the cumulative effects of all activities and trends affecting environmental justice issues over the next 40 years is expected to be negligible to minor. The cumulative effects would be concentrated in coastal areas, and particularly Louisiana. Most OCS Program effects are expected to be in the areas of job creation and the stimulation of the economy, and they are expected to make a positive contribution to economic justice. The contribution of the cumulative OCS Program to the cumulative impacts of all factors affecting environmental justice is expected to be minor (USDOI, MMS, 2001c); therefore, the incremental contribution of the CPA proposed action to the cumulative impacts would also be minor. State offshore leasing programs in Alabama and Louisiana have similar, although more limited effects, due to their smaller scale. Cumulative effects from onshore infrastructure, including waste facilities, is also expected to be minor because existing infrastructure is regulated, because little new infrastructure is expected to result in the cumulative case, and because any new infrastructure would be subject to relevant permitting requirements. Coastal landloss/subsidence, hurricanes, and global warming all raise environmental justice issues, as do the lingering effects of the DWH event. The cumulative consequences to environmental justice cannot be determined at this time. Nevertheless, a single OCS lease sale, State leasing programs, and onshore infrastructure would make only minor contributions to these cumulative effects.

4.1.1.22. Additional Resources Considered due to the Deepwater Horizon Event

The following resources, i.e., soft bottoms and diamondback terrapins, have not been included in previous EIS's due to the negligible impacts to these resources from routine impact-producing factors associated with OCS-related activities. The BOEMRE has included these resources in this Supplemental EIS primarily to address concerns about the potential impacts of the DWH event and resulting oil spill to these resources.

4.1.1.22.1. Soft Bottoms

4.1.1.22.1.1. Description of the Affected Environment

The seafloor on the continental shelf in the Gulf of Mexico consists primarily of muddy to sandy sediments. The eastern shelf is primarily sand extending out to 100-m (328-ft) water depth, while the central and western shelf is a mixture of sand, silt, and clay (Brooks and Darnell, 1991). Sediments near the shoreline of the Alabama coast consist of fine-grained, well-sorted sand and transition to clay and marl (Ellwood et al., 2006; Balsam and Beeson, 2003). Sediments offshore of Mississippi and Louisiana are primarily silt and clay of terrigenous origin (Ellwood et al., 2006; Balsam and Beeson, 2003).

Benthic fauna include infauna (animals that live in the substrate, including mostly burrowing worms, crustaceans, and mollusks) and epifauna (animals that live on or are attached to the substrate; mostly crustaceans, as well as echinoderms, mollusks, hydroids, sponges, soft and hard corals, and demersal fishes). Infauna is comprised of meiofauna, small organisms (63-500 μ) that live among the grains of

sediment; and macroinfauna, slightly larger organisms (>0.5 mm; 0.02 in) that live in the sediment (Dames & Moore, Inc., 1979). Shrimp and demersal fish are closely associated with the benthic community. The most abundant organisms on the continental shelf are the deposit-feeding polychaetes. The slope and deep sea consist of vast areas of primarily fine sediments that support benthic communities with lower densities and biomass but higher diversity than the continental shelf (Rowe and Kennicutt, 2001). The following information is an entirely new section since the writing of the Multisale EIS and the 2009-2012 Supplemental EIS and will be described in full.

Environmental Influences on Benthic Community Structure

Substrate is the single most important factor in the distribution of benthic fauna (densities of infaunal organisms increase with sediment particle size), although temperature and salinity are also important in determining the extent of faunal distribution (Vittor, 2000; Byrnes et al., 1999; Harper, 1991; Dames & Moore, Inc., 1979; Parker et al., 1975; Barry A. Vittor & Associates Inc., 1985; Defenbaugh, 1976). Depth and distance from shore also influence the benthic faunal distribution (Harper, 1991; Dames & Moore, Inc., 1979; Defenbaugh, 1976; Parker et al., 1975). Lesser important factors include illumination, food availability, currents, tides, and wave shock. Experiments indicate that fluctuating physical factors have a greater influence in estuaries than farther offshore, where sediment type is the primary influencing factor (Flemer et al., 2002).

Substrate type, as the most important control upon benthic infaunal assemblages, has been emphasized by previous sampling efforts over broad areas of the northern Gulf of Mexico shelf. Studies of the infauna of the Mississippi, Alabama, and Florida (MAFLA) OCS by Dames & Moore, Inc. (1979) revealed that inner shelf benthic habitats of the northeastern Gulf of Mexico can be described primarily on the basis of sediment texture and water depth. Barry A. Vittor & Associates, Inc. (1985) and Vittor (2000) categorized the OCS of the northern Gulf of Mexico based on sediment types and species associated with those habitats.

Infaunal assemblages are comprised of species adapted to particular sedimentary habitats through differences in behavioral, morphological, physiological, and reproductive characteristics. Feeding is one of the behavioral aspects most closely related to sedimentary habitat (Rhoads, 1974). In general, habitats with coarse sediment and high water current velocities, where organic particles are maintained in suspension in the water column, favor the occurrence of suspension-feeding taxa that strain food particles from the water column. Coarse sediments also facilitate the feeding of carnivorous taxa that consume organisms occupying interstitial habitats (Fauchald and Jumars, 1979). At the other extreme, habitats with fine-textured sediments and little or no current are characterized by the deposition and accumulation of organic material, thereby favoring the occurrence of surface and subsurface deposit-feeding taxa. In between these habitat extremes are a variety of habitat types that differ with respect to various combinations of sedimentary regime, depth, and hydrological factors, with each habitat type facilitating the existence of particular infaunal assemblages (Barry A. Vittor & Associates, Inc., 1985). An east-to-west transition of sedimentary regimes, from predominantly sands along the west Florida shelf to silts and clays along the Louisiana shelf, was evident during previous regional studies. Infaunal assemblages varied along this east-west gradient as well (Barry A. Vittor & Associates, Inc., 1985).

Descriptions of Continental Shelf Soft-Bottom Benthic Communities

Vittor (2000) described the general community composition of the infaunal habitats on the OCS of the northern Gulf of Mexico. He described the communities primarily based on sediment type and distance from shore and grouped the inhabitants by feeding mode.

- Assemblage I consisted of sandy sediments (<5% silt/clay or gravel) spread along the entire continental shelf. Dominant filter feeders on the shelf were mollusks (*Astarte nana*, *Chione intapurpurea*, *Ervilia concentrica*, *Tellina aequistriata*). Deposit feeders included mollusks (*Caecum cooperi, Caecum imbricatum, Cadulus tetrodon*) and ostracods (*Rutiderma darbyi*). Carnivores included polychaetes (*Nephtys picta*, *Sigambra tentaculata*, *Synelims albini*) and mollusks (*Nassarius albus, Tectonatica pusilla*).

- Assemblage II consisted of silty sand and sandy silt on the inner shelf in less than 100 m (328 m) of water. These areas generally have greater than 5 percent or 10 percent silt and are affected by sediment transport from estuaries. Burrowing and surface deposit-feeding polychaete detritivores such as *Armandia maculata*, *Dispio uncinata*, *Magelona petiboneae*, *Paraprionospio pinnata*, and *Spiophanes bombyx* inhabit this habitat. Filter-feeding crustaceans (*Ampelisca agassizi*, *Branchiostoma* sp.) and polychaetes (*Diopatra cuprea*, *Owenia fusiformis*) are also abundant.

- Assemblage III is comprised of patchy coarse sand or gravel. Deposit feeders in this group include mollusks (*Caecum cooperi*), amphipods (*Metharpinia floridana*), tanaids (*Apseudes* sp.), and polychaetes (*Aonides paucibranchiata*, *Chone duneri*, and *Filograna implexa*). *Chloeia viridis*, *Eunice vittata*, *Nephtys picta*, and *Bhawania heteroseta* are resident carnivores.

- Assemblage IV is comprised of fine and silty sand habitats in >100 m (328 m) of water. The most abundant organisms are the burrowing and surface deposit feeders including polychaetes (*Ampharete acutifrons*, *Aricidea neosuecica*, *Armandia maculata*, *Laonice cirrata*, *Poecilochaetus johnsoni*) and mollusks (*Nuculana acuta*, *Yoldia liorhina*). Polychaete carnivores/omnivores also include *Goniada maculata*, *Paralacydonia paradoxa*, and *Synelmis albini*.

Vittor (2000) based his community assemblages on his previous (Barry A. Vittor & Associates, Inc., 1985) descriptions of the continental shelf habitats between Florida and Louisiana. Barry A. Vittor & Associates, Inc. (1985) recognized four depth-related benthic habitats for infaunal communities in the region of the northeastern Gulf of Mexico: shallow beach habitat; inner shelf habitat; intermediate shelf habitat; and outer shelf habitat. Each of these habitats was further divided into sediment type (mud, sandy mud, muddy sand, or sand). Infaunal assemblage associations were recognized with each combination of water depth and substratum type. Cluster analysis revealed that infaunal taxa were closely tied to sediment type and texture.

The benthic habitat descriptions were a result of compiled habitat data collected from several studies conducted in the Tuscaloosa Trend regional area from the Florida to Louisiana shelves. Barry A. Vittor & Associates (1985) noted that the sediment is sandier on the Florida shelf and transitions to terrigenous silts and clays on the southeast Louisiana shelf. Sediment also becomes finer in the offshore direction. The following material describes the macroinfauna and macroepifauna communities to the east of the Mississippi River.

- Shallow Beach Habitat is located in 2-4 m (7-13 ft) of water and consists of well sorted sand and shell fragments. Temperature and salinity fluctuate and wave action is heavy. Dominant species include bivalves (*Donax* spp.), echinoderms (*Mellita quinquiesperforata*), and amphipods (*Protohaustorius* spp.).

- Inner Shelf Habitat is located in 4-20 m (13-66 ft) of water and is adjacent to barrier islands. Species in this area tolerate lower salinities resulting from Mississippi River freshwater input. Infaunal species that dominate in muddy (<20% sand) portions of this area include a hemichordate (*Balanoglossus aurantiacus*), a polychaete (*Paramphinome* sp.), and mollusks (*Utriculastra canaliculata*, *Nassarius acutus*). Epifaunal inhabitants include a sea pansy (*Renilla mulleri*), mollusks (*Nassarius acutus*, *Nuculana concentricia*), shrimp (*Farfantepenaeus aztecus*, *Litopenaeus setiferus*, *Rimapenaeus similis*), and crabs (*Portunus* spp., *Callinectes similis*). Echinoderms (*Hemipholis elongate*, *Micropholis atra*), mollusks (*Nuculana concentrica*), and crustacea (*Pinnixia pearsei*) are found in sandy mud habitats (20-50% sand). Infaunal species found in sandy (>90% sand) habitats include polychaetes indicative of offshore environments (*Nephtys picta*, *Dispio uncinata*, *Onuphis nebulosa*, *Magelona riojai*, *Aricidea wassi*, *Apoprionospio pygmaea*, *Brania wellfleetensis*), amphipods (*Acanthohaustorius* sp., *Protohaustorius* sp., *Lepidactylus* sp.), the cephalochordate (*Branchiostoma carribeum*), and the archiannelid

(*Polygordius* sp.), which are common in tidal inlets. Epifaunal species in this habitat include a sea pansy (*Renilla mulleri*), baby's ear gastropod (*Sinum prospectivum*), bivalves (*Noetia ponderosa*, *Chione clenchi*), brown shrimp (*Farfantepenaeus aztecus*), purse crabs (*Persephone* spp.), shame-faced crabs (*Calappa sulcata*, *Hepatus epheliticus*), and echinoderms (*Hemipholis elongate*, *Mellita quinquiesperforata*). Transitional polychaete species that thrive in both environments include *Magelona phyllisae*, *Paraprionospio pinnata*, *Mediomastus californiensis*, *Sigambra tentaculata*, and *Spiophanes bombyx*.

- Intermediate Shelf Habitat is located in 20-60 m (66-197 ft) of water and is comprised of both sand and mud environments. Muddy sediments are dominated by polychaetes (*Cirrophorus lyriformis*, *Nephtys incise*, and *Notomastus daueri*). Organisms in the sandy areas include polychaetes (*Aricidea wassi*), amphipods (*Metharpinia floridana* and *Ampelisca agassizi*), and tanaids (*Kalliapseudes* sp.). Polychaetes found in both sandy and muddy environments include *Cossura soyeri*, *Nereis micromma*, *Sigambra tentaculata*, and *Aglaophamus verrilli*. Epifaunal species found on the Intermediate Shelf Habitat include gastropods (*Strombus* sp., *Murex* sp., *Busycon* sp., *Fasciolaria* sp.), bivalves (*Argopecten* sp., *Tellina* sp., *Pitar* sp.), shrimps (*Penaeus* sp., *Sicyonia* sp.), crabs (*Calappa* sp., *Portunnus* sp., *Anasimus* sp., *Libinia* sp., *Parthenope* sp.), echnioids (*Encope* sp., *Stylocidaris* sp.), and starfish (*Luidia* sp., *Astropecten* sp.).

- Outer Shelf Habitat is comprised of mud (<20% sand) with the infauna characterized by polychaetes (*Notomastus latriceus*, *Nereis grayi*, *Cirrophorus lyriformis*, *Nephtys incisa*, *Paraprionospio pinnata*, *Mediomastus califirniensis*). A variety of epifauna are found in this zone including gastropods (*Turritella exoleta*, *Polystira albida*), bivalves (*Anadara* spp., *Verticordia ornate*), crabs (*Munida* sp., *Raninoides* sp., *Myropsis* sp.), echinoids (*Echinocardium* sp., *Brissopsis* sp.), and starfish (*Astropecten* sp., *Cheiraster* sp.).

Researchers from Texas A&M University collected benthic infauna and epifauna between the Mississippi Delta and De Soto Canyon as part of the Mississippi-Alabama Continental Shelf Ecosystem Study. Polychaetes dominated the macroinfauna, comprising 58.3 percent of the specimens taken, followed by bivalves and amphipods, comprising 12.2 percent and 9.4 percent of the specimens collected (Harper, 1991). The density of the infaunal species was related to the sediment type where the highest densities were found in coarse sediments and lowest densities were found in slit and clay. Organism diversity and abundance also decreased with depth. Of the epifaunal species collected, decapods (primarily shrimp) made up over 77 percent, echinoderms made up over 9 percent and mollusks made up over 7 percent of the specimens taken (Harper, 1991). The decapods showed seasonal migration where they moved inshore to the Louisiana marshes during the summer and offshore during the winter (Harper, 1991).

Infaunal surveys of sand resources identified off the coast of Alabama described seasonal variation in dominant species. Sandy habitats were dominated by the gastropods *Caecum pulchellum* and *Caecum cooperi* (Byrnes et al., 1999). These two species were dominant in samples collected in both May and December; however, May surveys also had high numbers of spionid polychaetes (*Paraprionospio pinnata* and *Spiophanes bombyx*), while December surveys had high numbers of the archiannelid *Polygordius*, the polychaete *Scoletoma verrilli*, and the amphipod *Eudevenopus hondurans* (Byrnes et al., 1999). Infaunal species richness was much higher in May than December, and assemblage was determined by grain size (Byrens et al., 1999), as reported by Harper (1991). Sandy sediments had high numbers of archiannelids (*Polygordius*), lancelet (*Brachiostoma*), and polychaete (*Spiophanes bombyx*), while finer sediments had greater numbers of the polychaetes *Mediomastus* and *Paraprionospio pinnata* (Byrnes at al., 1999).

Epifaunal invertebrates collected off the Alabama coast were dominated by the roughneck shrimp (*Trachypenaeus constrictus*), squid (*Loligo* sp.), striped sea star (*Luidia clathrata*), and rock shrimp (*Sicyonia* spp.) (Byrnes et al., 1999). May surveys were numerically dominated by striped sea star, squid, and roughneck shrimp, while December surveys were dominated by roughneck shrimp, squid, penaeid shrimp, and rock shrimp (Byrnes et al., 1999).

Dames & Moore, Inc. (1979) collected meiofaunal, macroinfaunal, and macroepifaunal samples along the Mississippi-Alabama-Florida OCS during a MAFLA baseline environmental survey. Although many samples were collected to the east of the CPA, some samples were collected in the CPA. Those samples collected outside of the area were composed of similar organisms due to similar benthic environmental conditions in the northern Gulf of Mexico, and they may be used in determining trends.

Nematodes and harpacticoid copepods are the most abundant meiofauna on the OCS of the northern Gulf of Mexico. Higher densities were recorded closer to shore, and they decreased with distance offshore. Densities tended to be highest in medium to fine sediments with a moderate to high carbonate composition (Dames & Moore, Inc., 1979). The macroinfauna were dominated by polychaetes. Macroinfauna also had the highest densities inshore and decreased offshore, and the greatest diversity occurred within 30-60 m (98-197 ft) of water. Density, however, decreased with decreasing grain size. Macroepifauna was dominated by crustaceans and mollusks, followed by echinoderms and coelenterates, and the macroepifauna followed the same density gradient offshore as the meiofauna and macroinfauna.

Non-OCS Oil and Gas Program Threats to Benthic Communities

The benthic communities are threatened by two natural environmental perturbations that occur on the Louisiana-Texas continental shelf: hypoxic to anoxic bottom conditions and tropical storms. Hypoxic conditions occur annually with inconsistent intensities and ranges (Rabalais et al., 2002). On average, one tropical storm of varying intensity occurs on the Louisiana continental shelf every 4 years (Stone, 2001).

The Gulf of Mexico hypoxic zone is a band that stretches along the Louisiana-Texas shelf each summer where the dissolved oxygen concentrations are less than 2 ppm. It is one of the largest hypoxic areas in the world's coastal waters. The hypoxic zone is the result of excess nutrients, primarily nitrogen, in the water. More than half the nitrogen comes from nonpoint sources about the confluence of the Ohio and Mississippi Rivers. A large variability in river discharge exists from year to year (Nowlin et al., 1998). Measurements of suspended particulate matter in the area of the proposed action have found concentrations from <1 to 10 mg/L. The rivers' effects on temperature and salinity have been detected as far west as Galveston (Murray and Donley, 1996).

Storms can physically affect shallow-bottom environments, causing an increase in sedimentation, a rapid change in salinity or dissolved oxygen levels, storm surge scouring, and remobilization of contaminants in the sediment (Engle et al., 2008). Storms have also been shown to uproot benthic organisms from the sediment and suspend them in the water column (Dobbs and Vozarik, 1983). Studies conducted in the coastal waters of Louisiana, Mississippi, and Alabama 2 months after the passing of Hurricane Katrina revealed a significant decrease in the number of species, species diversity, and species density (Engle et al., 2008). The opportunistic polychaetes *Mediomastus ambiseta* and *Paraprionospio pinnata* dominated benthic communities 2 months after the storm, and some other species were completely missing from the community (Engle et al., 2008). Evidence shows that communities are not completely restructured after a storm event, but there may be a dominance shift, at least temporarily (Dobbs and Vozarik, 1983).

The frequent disturbances on the inner shelf cause the infaunal community to be dynamic and unstable and to remain at an immature level of development, compared with a mature and stable community comprised of large, deep-dwelling, head-down deposit feeders. Transitional taxa are able to numerically dominate habitats that experience various perturbations, including siltation, low salinity, and low levels of dissolved oxygen (hypoxia) (Thistle, 1981; Rabalais et al., 2002). Recolonization of depurated areas by populations from unaffected neighboring soft-bottom substrate would be expected to occur within a relatively short period of time (Dubois et al., 2009; Thistle, 1981). Initial repopulation from nearby stocks may begin with subsequent recruitment or immigration events and may be predominantly comprised of pioneering species, such as tube-dwelling polychaetes or oligochaetes (Rhodes and Germano, 1982). Full recovery will follow as later stages of successional communities overtake the opportunistic species (Rhodes and Germano, 1982), but the time it takes to reach a climax community may vary depending on the species and degree of impact. This environmental unpredictability selects for opportunistic organisms that rapidly reach sexual maturity and produce large quantities of offspring repeatedly throughout the year. Species requiring an extended growth and development period or more constant environmental conditions may not survive to maturity. These

environmental threats tend to produce communities with lower biodiversity and biomass since longer-lived species tend to be eliminated.

Deepwater Horizon Event Impacts on Soft-Bottom Benthic Communities

The following sections contain all new data since the Multisale EIS and the 2009-2012 Supplemental EIS were prepared. Extensive literature, Internet, and database searches have been conducted for results of scientific data on soft-bottom benthic communities following the DWH event. Although many research cruises have occurred, very few reports containing data have been released as of the writing of this document. Descriptions of studies completed or in progress are discussed and any results indicated are included. Also, because the impacts of the oil spill are not yet known, possible impacts to soft-bottom benthic communities as a result of oil exposure are discussed.

As discussed earlier, the majority of the seafloor of the Gulf of Mexico is covered in soft sediments. Oil released from the DWH event may have impacted some of the organisms that live on or in these sediments. Direct contact with high concentrations of oil may have resulted in acute toxicity to organisms, and lower concentration exposures may have resulted in sublethal impacts such as altered reproduction, growth, respiration, excretion, chemoreception, feeding, movement, stimulus response, and susceptibility to disease (Suchanek, 1993). These impacts may occur through exposure pathways at the sediment/water interface or in the sediment itself.

It is important to note that the effects of oil exposure to soft-bottom benthos are anticipated to have only impacted a very small portion of the seafloor of the Gulf of Mexico. Although approximately 4.64 million barrels of oil were released into the Gulf waters, not all of that oil reached the seafloor. It is estimated that 26 percent of the released oil remains in the environment as oil on or just below the water surface as a light sheen or tarballs, oil that was washed ashore or collected from the shore, and oil that is in the sediments (Lubchenco et al., 2010). This residual oil has been degrading over time. The greatest concentrations are expected to be near the wellhead and decrease with distance from the source. The modes of transport to the seafloor discussed below are anticipated to only deliver a small amount of oil to the seafloor with decreasing concentrations away from the well.

Water Column and Sediment Water Interface Exposure

Although a portion of the oil that was released rose to the sea surface, because the oil was ejected under pressure, oil droplets become entrained deep in the water column. The upward movement of the oil was reduced because methane in the oil was dissolved at the high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). The large oil droplets rose to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume and the subsea injection of dispersants, remained neutrally buoyant in the water column, creating a subsurface plume of oil (Adcroft et al., 2010). Oil droplets less than 100 μm (0.0036 in) in diameter remained in the water column for several months (Joint Analysis Group, 2010a). Organisms may have been exposed to oil droplets in the water column (if they are mobile) or at the seafloor/water interface.

Also, some chemically dispersed oil may have reached the seafloor, but presumably in very low concentrations. It is reported that chemically dispersed surface oil from the DWH event remained in the top 6 m (20 ft) of the water column where it mixed with surrounding waters and biodegraded (Lubchenco et al., 2010). Data from other studies on dispersant usage on surface plumes indicates that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to stick to particles in the water column, minimizing the ability of dispersed surface oil to sediment to particles and travel to the seafloor (McAuliffe et al., 1981a). Any dispersed oil that reached the seafloor from the water's surface during this event would be expected to be at very low concentrations (less than 1 ppm) (McAuliffe et al., 1981a).

Oil dispersed in the subsurface plume may have also reached the seafloor. However, as with the surface dispersed oil, concentrations reaching the seafloor would be extremely low. Concentrations of dispersed and dissolved oil in the subsea plume were reported to be in the part per million range or less and decrease with distance from the wellhead (Lubchenco et al., 2010; Adcroft et al., 2010; Joint Analysis Group, 2010a). A recent report documents damage to a deepwater coral community in an area that oil plume models predict as the direction of travel for subsea oil plumes from the DWH event. Results are

still pending but it appears that a coral community about 15 m x 40 m (50 ft x 130 ft) in size was severely damaged and may have been the result of oil impacts (USDOI, BOEMRE, 2010j). A major difference between this occurrence and likely effects on soft bottoms is that the coral community forms structures that protrude up into the water column. These upright corals would be affected by a passing oil plume in a way that a typical smooth soft bottom would not. The oil plume would pass over smooth soft bottom, continuing the process of biodegradation in mid-water and continuing to be dispersed over a wide area. Dispersed oil may also come in contact with benthic organisms that move into the water column or at the sediment/water interface. However, during the passage of an oil plume, benthic filter or suspension feeders have the ability to simply withdraw into the substrate until water quality improves.

There is very little data available on the impacts of the DWH event on benthic communities. There is no data to date on the concentrations of hydrocarbons in sediments or on benthic community structure on the seafloor of the Gulf of Mexico after this event. There are, however, a few data available on hydrocarbons and dissolved oxygen levels in the water column. Water column data may be used to speculate the exposures benthic organisms may have experienced at the sediment/water interface.

Water samples collected by the R/V *Weatherbird* on May 23-26, 2010, located 40 nmi and 45 nmi (46 mi and 52 mi; 74 km and 83 km) northeast and 142 nmi (163 mi; 263 km) southeast of the DWH rig revealed that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm (Haddad and Murawski, 2010). The total petroleum hydrocarbons concentrations were generally higher near the water's surface and closer to the wellhead (Haddad and Murawski, 2010; Joint Analysis Group, 2010a). Concentrations of dispersed and dissolved oil in the subsea plume were reported to be in the part per million range or less and decrease with distance from the wellhead (Lubchenco et al., 2010; Adcroft et al., 2010; Joint Analysis Group, 2010a).

The hydrocarbon concentrations in the water column and subsea plume were close to, and below, the values reported by others for dispersed oil in the water column after oil spills. McAuliffe et al. (1981a) reported dispersed oil concentrations between 1 and 3 ppm, 9 m (30 ft) below the sea surface, 1 hour after treatment with dispersant, and Lewis and Aurand (1997) reported dispersed oil concentrations <1 ppm, 10 m (33 ft) below the sea surface. Although McAuliffe et al. (1981a) and Lewis and Aurand (1997) did not address subsea plumes, the oil concentrations in the subsea plume appear to be similar to the concentrations reported from surface use of dispersants (Lubchenco et al., 2010; Adcroft et al., 2010; Joint Analysis Group, 2010a).

The available data suggest that the concentrations of oil in the water column were low and the oil was dispersed. This data suggest that, if any benthic organisms at the sediment/water interface were exposed to oil as a result of the DWH event, the concentrations were very low (in the part per million range or less).

Hypoxia from Oil Biodegradation

Reduced oxygen conditions, or hypoxia, caused by the presence of oil in the water column and resultant break down of petroleum hydrocarbons by bacteria was also a concern. Numerous stations were sampled throughout the Gulf of Mexico by several research vessels between May 8 and August 9, 2010. Measured dissolved oxygen levels never reached hypoxic conditions (1.4 ml/L or 2 mg/L) and, in fact, were never below 2.5 ml/L at any station sampled (Joint Analysis Group, 2010a and 2010b).

A subsea hydrocarbon plume, which generally trended southwest from the release at the wellhead, was discovered during sampling events (Joint Analysis Group, 2010a). Dissolved oxygen anomalies were measured at 1,000-1,400 m (3,281-4,593 ft) below the sea surface, which corresponded to the depths that hydrocarbons from the DWH event were located (Joint Analysis Group, 2010b). Models indicated that hypoxic levels may be reached in the subsea plume when methane is oxidized (Adcroft et al., 2010). Field measurements indicated that these dissolved oxygen depressions, however, did not approach hypoxic levels as of August 9, 2010 (Joint Analysis Group, 2010b). The dissolved oxygen in the water column did not appear to be decreasing over time, indicating that the oil was mixing with the surrounding oxygen-rich water (Joint Analysis Group, 2010b).

Dissolved oxygen measurements taken at the seafloor between May 15 and May 25 were between 4.0 and 5.0 ml/L (Joint Analysis Group, 2010a). Dissolved oxygen was toward the lower end of the measurements south and southwest of the wellhead and was toward the higher end to the north and northwest of the wellhead (Joint Analysis Group, 2010a). This is the most recent data released for

dissolved oxygen levels on the seafloor at the time of this writing. Dissolved oxygen levels of this concentration are far above the hypoxic range (<1.4 ml/L) and are not anticipated to result in loss of the benthic population.

A yearly hypoxic event on the continental shelf of the northern Gulf of Mexico off the Mississippi and Atchafalaya Rivers result in bottom oxygen levels dropping below 1.4 ml/L (2 mg/L) for prolonged periods during the spring through late summer (Rabalais et al., 2002). This hypoxic event results in lower dissolved oxygen levels than what were measured in the water column and bottom waters as a result of the DWH event (Joint Analysis Group, 2010a and 2010b; Haddad and Murawski, 2010). The yearly hypoxia results in most of the benthic organisms leaving the area or dying; however, data indicates that the benthic colonies recolonize yearly after this event (Rabalais et al., 2002; Diaz and Solow, 1999). This pattern of yearly disturbance and recruitment favors opportunistic species (for organisms that die as a result of the hypoxia), resulting in a community composition that does not reach its climax.

Based on the above water column and seafloor data, benthic communities would not have been lost due to hypoxia caused by the DWH event. Naturally occurring, yearly annual events cause lower dissolved oxygen levels than what were recorded as a result of the DWH event. The yearly hypoxic zone would likely have occurred during the DWH event and resulting spill, with its typical effects. However, if any organisms were lost due to reduced oxygen levels caused by natural occurrences or by biodegradation of oil in the environment, they should recolonize the area similarly to the yearly hypoxic event.

Sedimented Oil (Oil Adsorbed to Sediments)

Some of the smaller suspended oil droplets resulting from forceful injection at depth could have been carried to the seafloor as a result of oil droplets sedimenting to suspended particles in the water column. Some portion of the oil treated with dispersant, although having less affinity for adhering to suspended sediment, may still have settled to the seafloor before completely biodegrading. Oiled sediment that settled to the seafloor may affect the underlying organisms. It is not yet known how much oil sedimented to particles and settled to the seafloor. If large amounts of oil made its way to the seafloor, the underlying benthic communities may have been smothered by the particles or exposed to toxic hydrocarbons. It is anticipated that the greatest concentration of sedimented oil occurred close to the well; oil would continue to disperse over wider areas with lower concentrations as it travels farther from the source (Haddad and Murawski, 2010; Joint Analysis Group, 2010a).

Acute Toxicity and Recovery

The greatest threat to the benthic communities is anticipated to be the sedimented oil that may reach the seafloor. Because oil concentrations decreased in the water column away from the well, the highest sedimented oil concentrations should be in areas closer to the well. Soft-bottom infaunal communities near the wellhead may have been negatively impacted by direct contact with sedimented oil and may experience sublethal (exposure) and/or lethal (smothering) effects.

Localized areas of lethal effects will be recolonized by populations from neighboring soft-bottom substrate once the oil in the sediment has been sufficiently reduced to support marine life (Sanders et al., 1980). Opportunistic species, such as tube-dwelling polychaetes or oligochaetes, will be the first to appear. These species will occur within the first recruitment cycle of the surrounding populations and from species immigrating from surrounding stocks (Rhodes and Germano, 1982). These pioneering species will maintain a stronghold in the area until community succession begins (Rhodes and Germano, 1982; Sanders et al., 1980). Full recovery would follow as later stages of successional communities overtake the pioneering species (Rhodes and Germano, 1982). The time it takes to reach a climax community may vary depending on the species and degree of impact. Full benthic community recovery may take years to decades if the benthic habitat is heavily oiled (Gómez Gesteira and Dauvin, 2000; Sanders et al., 1980; Conan, 1982).

One must be careful, however, in studying the impacts of the DWH event. One should not immediately designate benthic communities that contain pioneering species as areas that were defaunated as a result of the DWH event. Benthic populations in the Gulf of Mexico that experience yearly hypoxic events are permanently in early successional stages (Gaston et al., 1998; Diaz and Solow, 1999). These

communities are dominated by small, opportunistic, surface-feeding polychaetes and there is a lack of large, suspension-feeding bivalves (Gaston et al., 1998; Rabalais et al., 2002).

However, one may be able to presume that the early successional stage of a large area of the northern Gulf of Mexico reveals its ability to quickly recover from stressful events, such as yearly hypoxia in areas, and therefore suggests that the benthic community may also rapidly return to its prior state if it was impacted by oil. Recovery after hypoxic events has been reported to begin within 6 months, and full recovery to the original community state has been seen in 1-2 years, depending on other environmental disturbances (Diaz and Solow, 1999; Harper et al., 1991). Similar recovery times would be expected for most communities exposed to sedimented oil unless the area is heavily oiled and, therefore, recovery could take much longer (Gómez Gesteira and Dauvin, 2000; Sanders et al., 1980; Conan, 1982).

The areas that may be defaunated as a result of the DWH event are small compared with the area of the entire seafloor of the Gulf of Mexico. The greatest damage is anticipated to have occurred closest to the well where hydrocarbon readings were highest. Most of the seafloor is not anticipated to experience any impact from the event. In areas where low levels of oil reach the seafloor, sublethal or immeasurable impacts may occur.

Sublethal Impacts

Research on oil spilled from the Chevron Main Pass Block 41C Platform into the Gulf of Mexico has indicated that oil in bottom sediments can weather rapidly, leaving only a small percentage of the oil in the sediments after a year (McAuliffe et al., 1975). Substantial weathering was noted 1 week and 1 month after the Chevron Main Pass spill, and the oil remained in the top 1.5 in (3.8 cm) of the sediment. Benthic community fluctuations could not be correlated to the oil in the sediment from this oil spill, and the numbers of brown and white shrimp and blue crabs in the area of the oil spill did not appear to decrease 3 months or 1 year after the spill (McAuliffe et al., 1975). Although the volume of the Chevron Main Pass spill was much less than the spill that resulted from the DWH event, it is probable that oil on the seafloor will behave the same way and weather similarly.

The *Ixtoc* oil spill in the Bay of Campeche, Gulf of Mexico, was much more on scale with the volume of oil that entered the Gulf of Mexico. The *Ixtoc* blowout flowed for 290 days and resulted in an estimated 120,000 metric tons of oil reaching the seafloor (Jernelöv and Lindén, 1981). Oil reached the seafloor in small droplets in the offshore waters, although some aggregates formed nearshore. The approximate concentration of oil on the seafloor was 1 g/m^2, which is not high enough to cause substantial damage to a benthic ecosystem (Jernelöv and Lindén, 1981). Surface sediment samples collected mid- and post-spill did not reveal any hydrocarbons from the Ixtoc spill; however, hydrocarbons from this source were identified on suspended sediment in the water column (ERCO, 1982). This data show that the oil may take some time to reach the seafloor and when it does, it is widely dispersed.

As with the Chevron Main Pass spill, depressions in the benthic community during and following the *Ixtoc* spill could not be linked to the oil because hydrocarbons from the blowout were not present in sediment samples (ERCO, 1982). The benthic populations were depressed following the spill compared with pre-spill conditions; however, environmental evidence was not strong enough to separate oil impacts from natural variation or possible storm damage impacts (Tunnell et al., 1981). Oil may have been present in the sediment and affected benthic communities, but weathered before sampling occurred, or oil in the water column may have affected species, but these possible factors were not measured (Rabalais, 1990).

Regardless of the speculations, field measurements indicate that the concentrations of oil that reached the seafloor were low even after uncontrolled flow for a long period of time, and the oil was vastly dispersed by the time it reached the seafloor. The inability to measure hydrocarbons in the sediment after the spill suggested that any oil that reached the seafloor had weathered rapidly. It is anticipated that similar dispersion of oil, rapid weathering, and resultant low-level, widespread concentrations of oil on the seafloor will be measured from the DWH event.

Long-Term Impacts

Long-term or low-level exposure may also occur to benthic infauna as a result of oil adhering to sediment. Mesocosm experiments using long-term, low-level concentrations of No. 2 fuel oil indicate acute toxicity to meiofauna due to direct oil contact and sublethal effects from sedimented oil and

byproducts of the decomposition of the sedimented oil (Frithsen et al., 1985). Long-term exposure to low levels of fuel oil was shown to affect recruitment success; meiofaunal population recovery took between 2 and 7 months (Frithsen et al., 1985). These types of impacts would be expected farther from the well where oil concentrations were diluted with distance.

An increase in contamination levels in sediments can result in a decrease in trophic diversity and an increase in opportunistic pollution tolerant species (Gaston et al., 1998). Contaminated and disturbed areas are generally dominated by small, subsurface deposit feeders (Gaston et al., 1998). These small opportunistic species live at the sediment water interface and are more tolerant of contaminants (Gaston et al., 1998). Those species that can tolerate the disturbed or contaminated environment and recruit rapidly will be the initial colonizers of the area. Two pioneering Capitellid polychaetes in the Gulf of Mexico known to tolerate environmental stress are *Mediomastus californiensis* and *Notomastus latericeus*, and they can be expected in recovering areas (Gaston et al., 1998). Amphipods on the other hand, especially of the genus *Ampelisca*, are extremely sensitive to oil pollution and would not be found in the early recovery stages after hydrocarbon pollution (Gómez Gesteira and Dauvin, 2000). The pioneering community will remain until later successional organisms settle, or the pioneering stage may remain in continually disturbed areas, such as those affected by yearly hypoxia.

An alteration in the benthic trophic structure may impact food availability for fish and invertebrates. Burrowing polychaetes and subsurface deposit feeders are not important in the diets of the red drum and spotted sea trout, two commercially and recreationally important species in the Gulf of Mexico (Gaston et al., 1998). Therefore, an increase in opportunistic species will result in less available food for certain species of fish (Gaston et al., 1998). The small surface-dwelling opportunistic species, however, appear to be important in the diet of juvenile brown shrimp (McTigue and Zimmerman, 1998) and therefore may provide additional food sources for this species. Early stage successional communities, however, cannot store and regulate the nutritional energy that a later stage community can because the organisms are small and remain at the sediment surface, resulting in a less stable and productive food source for higher trophic levels (Diaz and Solow, 1999).

Studies to Measure the Impact of the *Deepwater Horizon* Event

Many studies have been planned to analyze the impact of the DWH event, and some have already been carried out. The limited data currently available on the impacts of the DWH event make it difficult to definitively describe any impacts that have occurred or may occur to the benthic communities in the CPA. However, the long-lasting impacts of this event will take years to determine. As more studies are conducted and more data are released, we will have a better understanding of the breadth of the effects of the DWH event and possible long-term effects.

4.1.1.22.1.2. Impacts of Routine Events

Background/Introduction

The vast majority of the Gulf of Mexico seabed is comprised of soft sediments. These soft-bottom benthic communities of the CPA are described in **Chapter 4.1.1.22.1.1**. Impacts from routine oil and gas activities to the soft-bottom benthic communities are discussed in this section, as a majority of the oil and gas exploration would be conducted in soft seafloor sediments. This is an entirely new section, as soft-bottom benthic community impacts were not discussed in the Multisale EIS or the 2009-2012 Supplemental EIS. Impacts to these communities include infrastructure emplacement, turbidity and smothering, drilling-effluent and produced-water discharges, and infrastructure removal. Disturbances of soft-bottom communities may cause localized disruptions to food sources for some large invertebrate and finfish species.

It is important to note that the effects of routine events on soft-bottom benthos would only impact a very small portion of the 268,922 km^2 (103,831 mi^2) of seafloor in the CPA. Impacts from the drilling of wells are generally confined to a few hundred meters from the well and impacts decrease with distance from the well. Recovery from construction impacts should begin within a year but may take several years to complete recovery (Rhodes and Germano, 1982; Neff et al., 2000; Newell et al., 1998). Recovery would depend on the benthic community composition, sediment type, and the intensity of the disturbance.

Long-term operational impacts are localized and generally result in a shift in benthic community dominance (Montagna and Harper, 1996).

Construction Impacts on Infauna and Soft-Bottom Benthic Communities

Organisms from the bacterial level up through polychaete worms and crabs inhabit the soft-bottom benthos. Many of these organisms form the base of the food chain for larger invertebrates and finfish species. Any immobile benthic organisms that are in the footprint of the infrastructure or pipeline emplacement would be physically crushed. The soft-bottom habitat would be replaced with a hard substrate for the life of the structure; for some, such as pipelines or seafloor templates that are abandoned in place at the end of their service, the substitution of hard bottom is permanent. While the substrate and community are changed, the change is generally considered an improvement in value and ecological services. This hard substrate would supply a foundation upon which encrusting organisms may settle (Gallaway and Lewbel, 1982). Encrusting organisms may include barnacles, oysters, mussels, bryozoans, hydroids, sponges, octocorals, corals, and algae (Gallaway and Lewbel, 1982). These organisms provide habitat and food for larger benthic organisms and finfish. The addition of a petroleum platform would result in a community shift from a soft-bottom infaunal community to a reef community above a soft-bottom benthic community. This shift provides more complex habitat, supporting more diverse assemblages than typical soft bottom. The shrimp trawling fishery is negatively affected to a small degree because structures create more obstacles to their trawling. There is also a reduction in trawlable area but this amount is so small compared with the available area (268,922 km^2; 103,831 mi^2) as to be insignificant.

The drilling of a well may result in water column turbidity, smothering of benthic organisms by the deposition of cuttings, coarsening of sediment near the well, trace metal contamination from cuttings, organic enrichment of the seabed, and hypoxic conditions if synthetic-based drilling fluid is used, and possible hydrocarbon contamination. Turbidity is a short-term impact as the cuttings rapidly sink to the seafloor. Burial of benthic communities and alteration of the sediment near the platform would result in the repopulation of smothered benthic habitats, possibly with different species that are adapted to coarser sediment. The impacts of long-term exposures to metals and hydrocarbons in the cuttings are discussed in the following section, as they occur during the lifetime of the project.

Drilling disposal methodology (surface disposal or bottom shunting) and drilling fluid (synthetic or water based) would result in slight differences in the dispersal of the well cuttings and drilling muds. For example, well cuttings that are disposed of at the water's surface tend to disperse in the water column and are distributed widely at low concentrations (CSA, 2004b; NRC, 1983). In deep water, cuttings discharged at the sea surface may spread out to 1,000 m (3,280 ft) from the source, depending on currents, with the thickest layers at the well and the majority of the sediment within 250 m (820 ft) (CSA, 2006a). On the other hand, cuttings that are shunted to the seafloor are concentrated over a smaller area in piles instead of being physically dispersed over wide areas (Neff, 2005). The heaviest concentrations of well cuttings and drilling fluids, for both water-based and synthetic-based drilling muds, have been reported within 100 m (328 ft) of well and are shown to decrease beyond that distance (CSA, 2004b; Kennicutt et al., 1996). Deposition may reach up to 500 m (1,640 ft) from the well, depending on surrounding environmental conditions (Kennicutt et al., 1996).

Surface-released cuttings rarely accumulate thicknesses of about 1 m (3 ft) immediately adjacent to the well; thicknesses are usually not higher than a few tens of centimeters (about 1 ft) in the GOM. A gradient of cuttings that encompasses most of the cuttings settles within 100 m (328 ft) of the well site. Cuttings settle in a patchy distribution determined by water currents and limited to about 250 m (820 ft) from the well site (CSA, 2004b). Impacts would be less in shallow waters than deep waters, as the shallow water organisms have greater vertical migration ability in the sediment than the deepwater benthos (CSA, 2004b). Because cuttings are distributed unevenly and in patches, burial would be localized (CSA, 2004b).

The greatest impact to the benthic community may result from the shunting of cuttings to the seafloor in order to protect nearby topographic features. Cuttings that are shunted to the seafloor form concentrated thicker depositions over a smaller area of soft seafloor (Neff, 2005). Any organisms beneath heavy layers of deposited cuttings would be smothered.

Additional stress may occur if synthetic drilling fluids are used. Base fluids of synthetic drilling muds that remain on the cuttings are designed to be low in toxicity and biodegradable in offshore marine sediments (Neff et al., 2000). However, as bacteria and fungi break down the synthetic drilling fluids, the sediments may become anoxic (Neff et al., 2000). Benthic macrofaunal recovery would occur when synthetic drilling mud concentrations are reduced to levels that enable the sediment to become reoxygenated (Neff et al., 2000). Complete community recovery from synthetic drilling mud exposure may take 3-5 years (Neff et al., 2000).

Sediment grain size may be altered near the new structure. Investigations have shown that sediments were enriched with sandy material out to 100 m (328 ft) from a well (Kennicutt et al., 1996). Altered grain size can result in different species inhabiting the sediment.

Recolonization and immigration by organisms from neighboring soft-bottom substrate to the impacted areas would be expected to occur within a relatively short period of time. Initial repopulation from nearby stocks may begin with the following recruitment event and be predominantly comprised of pioneering species, such as tube-dwelling polychaetes or oligochaetes (Rhodes and Germano, 1982). Full recovery would follow as later stages of successional communities overtake the opportunistic species (Rhodes and Germano, 1982), but the time it takes to reach a climax community may vary depending on the species and degree of impact. Initial recovery should be well advanced within a year following the deposition (Neff, 2005). Because some benthic communities in the northern Gulf of Mexico are permanently in early community successional stages due to frequent disturbances, full recovery may occur very quickly (Rabalais et al., 2002; Gaston et al., 1998; Diaz and Solow, 1999).

Long-Term and Operational Impacts on Infauna and Soft-Bottom Benthic Communities

Benthic organisms may experience long-term impacts such as exposure to contaminants, alteration in habitat, and a change in community structure as a result of offshore oil and gas production. These impacts are generally localized and occur close to the production platform (within 100-200 m [328-656 ft] from the platform) (Montagna and Harper, 1996; Kennicutt et al., 1996; Hart et al., 1989; Kennicutt, 1995; CSA, 2004b). Sand content, metals, barium, inorganic carbon, and petroleum products have all been reported to be elevated near platforms (Kennicutt, 1995). Distribution of discharges tends to be patchy, have sharp gradients, and be directional (Kennicutt, 1995). The greatest impacts occur in low energy environments where depositions may accumulate and not be redistributed (Neff, 2005; Kennicutt et al., 1996). Despite these possible impacts, it is important to consider that they occur over a very small portion of the seafloor of the Gulf of Mexico. The CPA covers 268,922 km^2 (103,831 mi^2) and is mostly soft-bottom sediment.

Long-term impacts of oil and gas production have been studied in the Gulf of Mexico Offshore Monitoring Experiment and other monitoring programs. These programs indicated that the greatest long-term impacts to benthic organisms were from the deposition of drilling muds and cuttings on the seabed. Drilling mud is primarily composed of barium. Elevated levels of barium, silver, cadmium, mercury, lead, and zinc were found out to 200 m (656 ft) from platforms and are likely a product of drilling mud and cuttings (Kennicutt et al., 1996; Hart et al., 1989; Chapman et al., 1991; CSA, 2004b). The concentrations of metals decreased with distance from the platform and were highest in low energy environments (Kennicutt et al., 1996).

Other additions of metals to sediments near offshore platforms may come from produced waters and corrosion of the structure itself. Information is contradictory on the distance from a platform that produced waters can affect benthic communities. Impacts have been reported from 100 m (328 ft) of the source to 1 km (0.6 mi) from the source (Peterson et al., 1996; Armstrong et al., 1977; Osenberg et al., 1992). Elevated levels of lead, zinc, and cadmium in sediments near platforms are most likely deposited from produced waters and corrosion of the galvanized platform itself (Kennicutt et al., 1996). Lead concentrations have been reported to continue to accumulate in sediment during the lifetime of an offshore platform (Kennicutt et al., 1996). The continual addition of metals to sediment near platforms results in continuous exposure of benthos to the metals.

Metal concentrations in sediments near gas platforms have been reported above those that may cause deleterious biological effects. Sublethal infaunal impacts have been reported out to 100 m (328 ft) from the platform. Of the species sampled, harpacticoid copepods were most sensitive to contamination. They showed reduced abundances, reduced survival, and increased reproductive effort paired with reduced

recruitment closer to platforms (Montagna and Harper, 1996; Carr et al., 1996). Copepods showed reduced genetic diversity near platforms and the production efficiency of nematodes was found to be reduced by half within 50-100 m (164-328 ft) of a platform (Montagna and Li, 1997; Kennicutt, 1995). The impacts are believed to be a result of metal toxicity originating from drill cuttings that remain in the sediment during the installation of the well (Montagna and Harper, 1996; Carr et al., 1996).

Lethal impacts may also occur near the wells due to localized elevated metal concentrations in sediments from cuttings. Porewater toxicity as a result of metal contamination was detected near gas platforms (Carr et al., 1996). Sea urchin fertilization and embryological development were reduced within 150 m (492 ft) from gas platforms, as was polychaete reproduction and copepod nauplii survival (Carr et al., 1996; Kennicutt, 1995).

Hydrocarbon contamination as a result of regular gas production activities is relatively low (Montagna and Harper, 1996). Hydrocarbon enrichment has been reported within 25 m (82 ft) and out to 200 m (656 ft) of petroleum platforms, and the concentrations decreased with distance from the platforms (Hart et al., 1989; Chapman et al., 1991; Kennicutt, 1995; Kennicutt et al., 1996). The concentrations of PAH's in the sediment surrounding platforms, however, were below the biological thresholds for marine organisms and appeared to have little effect on benthic organisms (Hart et al., 1989; McDonald et al., 1996; Kennicutt et al., 1996). Other studies indicated that chronic low-level discharges from petroleum production in the northern Gulf of Mexico did not result in hydrocarbons accumulating to stressful levels in benthic organisms or resultant organism responses to the hydrocarbons (Sharp and Appan, 1982).

It is anticipated that hydrocarbon contamination at oil-producing wells is higher than for gas wells (Carr et al., 1996). Unlike with metals, links between petroleum products and benthic impacts are not established (Holdway, 2002; Southwest Research Institute, 1981). It is possible that petroleum hydrocarbons in drilling muds and cuttings may cause toxicity to benthic organisms and bioaccumulate up the food chain; however, very little information is available on such impacts (Neff, 2005). It is also possible that continuous influx of contaminants from the Mississippi River and periodic flooding and storms mask the impact to benthic organisms from chronic exposure to petroleum production (Southwest Research Institute, 1981). Variation in natural environments also makes it difficult to determine a link between petroleum production impacts and natural environmental impacts on benthic communities (Holdway, 2002).

The sedimentary environment surrounding a well may be altered by the disposal of cuttings on the seafloor. The sediment grain size near petroleum platforms was reportedly larger and enriched with sand compared with the surrounding environment (Kennicutt et al., 1996). Sediment was coarser within 100 m (328 ft) of a discharge site and sediment alterations have been reported out to 500 m (1,640 ft), depending on the surrounding environment and method of disposal (surface disposal or bottom shunting) (CSA, 2004b; Kennicutt et al., 1996). Sediment was coarser near the platform, becoming finer with distance (Hart et al., 1989; Kennicutt, 1995). The field of impact is not heterogeneous and there are often concentration gradients within the discharged material, which is often deposited directionally as it is carried by water currents (Kennicutt, 1995).

Metal and hydrocarbon concentrations and altered sediment characteristics near wells may result in an altered benthic population surrounding the production platform. Significant impacts to benthos as a result of sediment alteration were measured within a few hundred meters of petroleum platforms (Kennicutt, 1995). The benthic assemblages within 150 m (492 ft) of some wells differed from the infaunal deposit-feeding species farther from the well (Hart et al., 1989). Epifaunal organisms can be sloughed from the platform to the surrounding seafloor and the bottom community surrounding the platform may be similar to those associated with shell reefs, rubble bottoms, and hard substrates (Hart et al., 1989). The infaunal deposit-feeding species that are typical of the Gulf of Mexico seafloor become more prevalent with distance from the well.

Contaminants also reportedly altered benthic community structure in a 25- to 100-m (82- to 328-ft) radius surrounding platforms (Chapman et al., 1991; Montagna and Harper, 1996). In general, polychaetes, bivalves, nemerteans, decapods, and isopods all increased near platforms, while amphipods and foraminiferans, which are more sensitive to contamination, decreased near platforms and increased with distance from the well (Chapman et al., 1991; Montagna and Harper, 1996; Kennicutt, 1995). Deposit feeders are generally much less sensitive to environmental contaminants than the crustaceans, and reduced crustacean populations are likely the result of elevated metal concentrations near platforms resulting from well drilling, produced waters, and corrosion of the structure (Peterson et al., 1996).

Mobile epifaunal organisms do not show trends associated with distance from platforms. Instead, each platform is a unique community that is influenced by the physical and chemical parameters of the platform itself (Ellis et al., 1996). The platforms, however, act as artificial reefs, attracting encrusting organisms to the introduced structure. The colonization of platforms and resultant attraction of fish and mobile invertebrates may result in localized organic enrichment in sediments near the platforms (Montagna and Harper, 1996). Organic enrichment has been reported within 100 m (328 ft) of wells and may alter benthic communities where sediment is enriched (CSA, 2004b). Enriched sediments may lead to increased infaunal deposit-feeder density and diversity near platforms as reported by Montagna and Harper (1996). The number of organisms was reportedly greater within 100 m (328 ft) of platforms, most likely due to the organic enrichment near platforms (Kennicutt, 1995). Surveys indicate that, although the number of organisms was high within this radius, species diversity was low and dominated by a few opportunistic species (CSA, 2004b). Elevated, nonselective, deposit-feeding populations near platforms are likely the combined result of enriched organic material near the platforms as a result of "organic shedding" from platforms and opportunistic species populating defaunated sediment as a result of metal toxicity or anaerobic conditions (Peterson et al., 1996; Kennicutt, 1995; CSA, 2004b). Deposit feeders are able to utilize organic material in polluted areas as a food source, allowing them to feed in areas other organisms cannot tolerate (Peterson et al., 1996). Bivalves may also be found in organically enriched areas as many bivalves are able to tolerate low dissolved oxygen levels that can occur in such environments (CSA, 2004b).

Synthetic drilling fluids are designed to be nontoxic to marine organisms; however, as bacteria and fungi break down the synthetic drilling fluids, the sediments may become anoxic (Neff et al., 2000). The time it takes for the sediment to hold enough oxygen for organisms to populate the area may take several years (Neff et al., 2000). The time between drilling and repopulation may result in an altered benthic community. Monitoring of a drill site indicated that sediments out to 75 m (246 ft) from the site were anaerobic 4 months after drilling and benthic infauna abundance was low out to 200 m (656 ft) (CSA, 2004b). The opportunistic polychaete, *Capitella capitata*, was abundant out to 125 m (410 ft) from the drill site but was not found beyond 200 m (656 ft) from the well (CSA, 2004b). Evidence of recovery was observed a year after drilling occurred, especially at stations greater than 75 m (246 ft) from the well (CSA, 2004b). After 2 years, community structure had recovered, but species composition was slightly altered (CSA, 2004b). Biological effects appear to be a result of the organic enrichment from synthetic-based drilling fluid, and the resultant biodegradation and anaerobic conditions (CSA, 2004b).

It should be noted that the combined impacts of drilling wells may lead to unexpected ecological interactions surrounding wells. For example, infaunal deposit feeders are usually associated with finer sediments, but they are seen in the coarser sediments close to platforms. This is probably due to both tolerance to contaminants in the sediment and their ability to utilize organic enrichment in the sediment deposited by higher tropic levels or from the breakdown of synthetic drilling fluids. Epifaunal organisms, however, are those that associate with coarser sediments and reefs, as there is substrate on the reef and larger material in the sediment for attachment. These alterations lead to a local altered environment that is specific to each platform and its impacts on the surrounding environment (Montagna and Harper, 1996; Hart et al., 1989; Ellis et al., 1996).

An alteration in the benthic community may impact food availability for fish and invertebrates. Burrowing polychaetes and subsurface deposit feeders are not important in the diets of the red drum and spotted sea trout, two commercially and recreationally important species in the Gulf of Mexico (Gaston et al., 1998). Therefore, an increase in opportunistic species would result in less available food for certain species of fish (Gaston et al., 1998). The small surface-dwelling opportunistic species, however, appear to be important in the diet of juvenile brown shrimp (McTigue and Zimmerman, 1998) and therefore may provide additional food sources for this species. Early stage successional communities, however, cannot store and regulate the nutritional energy that a later stage community can because the organisms are small and remain at the sediment surface, resulting in a less stable and productive food source for higher trophic levels (Diaz and Solow, 1999). This impact on higher trophic levels may last as long as the alteration in benthic community structure does.

Structure-Removal Impacts

The impacts of structure removal on soft-bottom benthic communities can include turbidity, sediment deposition, explosive shock-wave impacts, and loss of habitat. Both explosive and nonexplosive removal operations would disturb the seafloor by generating considerable turbidity. Suspended sediment may evoke physiological impacts in benthic organisms including “changes in respiration rate, . . . abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus” (Anchor Environmental CA, L.P., 2003). The higher the concentration of suspended sediment in the water column and the longer the sediment remains suspended, the greater the impact. Also, different species have differing tolerances to suspended sediment. In general, polychaete worms can withstand much higher concentrations of suspended sediment in the water column than amphipods (Swanson et al., 2003). Bivalves can withstand high concentrations of suspended sediment by reducing net pumping rates and rejecting material in pseudofeces (Clarke and Wilber, 2000). Mobile organisms have a much better chance of escaping high suspended sediment concentrations and the possible resultant smothering than sessile organisms do because they can avoid areas of disturbance (Clarke and Wilber, 2000).

Structural removal may also result in resuspension of contaminated sediments (Schroeder and Love, 2004). The impact to benthic organisms as a result of contaminant exposure from suspended sediments is dependent on many variables and not well understood (Eggleton and Thomas, 2004). Acute toxicity, chronic impacts, and bioavailability would all be dependent on the changes in the physical and chemical environment as a result of the disturbance.

Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, reducing light intensity, and causing physical abrasion (Wilber et al., 2005). Many benthic organisms have the ability to tolerate some sedimentation, as they experience it through natural processes (Wilber et al., 2005). For example, organisms may vertically migrate up through deposited sediment (Wilber et al., 2005). If a different size sediment is deposited on the seafloor than what is presently there, the impacts may be greater than if the same grain size was deposited, and the habitat may be altered as a result (Wilber et al., 2005).

The shock waves produced by explosive structure removals damage some benthic organisms in the near vicinity of the blasts. O’Keeffe and Young (1984) described the impacts of underwater explosions on various forms of sea life using, for the most part, open-water explosions much larger than those used in typical structure-removal operations. They found that sessile benthic organisms, such as barnacles and oysters, and many motile forms of life, such as shrimp and crabs, that do not possess swim bladders were remarkably resistant to shock waves generated by underwater explosions. Oysters located 8 m (26 ft) away from the detonation of 135-kg (29-lb) charges in open water incurred a 5 percent mortality rate. Crabs distanced 8 m (26 ft) away from the explosion of 14-kg (31-lb) charges in open water had a 90 percent mortality rate. Few crabs died when the charges were detonated 46 m (151 ft) away. O’Keeffe and Young (1984) also noted “. . . no damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods.” Impacts to invertebrates are anticipated to be minimal as they do not have air bladders inside their bodies that may burst with explosions as some fish do (Schroeder and Love, 2004).

Benthic organisms appear to be further protected from the impacts of subbottom explosive detonations by rapid attenuations of the underwater shock wave traversing the seabed away from the structure being removed. The shock wave is significantly attenuated when explosives are buried as opposed to detonation in the water column (Baxter et al., 1982). Theoretical predictions suggest that the shock waves of explosives set 5 m (15 ft) below the seabed, as required by BOEMRE regulations, would attenuate blast effects (Wright and Hopky, 1998).

Infrastructure or pipeline removal would impact both the communities that have colonized the structures and the soft-bottom benthos surrounding the structure. Removal of the structure itself would result in the removal of the hard substrate and encrusting community. The overall community would experience a reduction in species diversity (both epifaunal encrusting organisms and the fish and large invertebrates that fed on them) with the removal of the structure (Schroerer and Love, 2004). The epifaunal organisms attached to the platform that are physically removed would die once the platform is

removed. However, the seafloor habitat would return to the original soft-bottom substrate that existed before the well was drilled.

Some structures may be converted to artificial reefs. If the platform stays in place, the hard substrate and encrusting communities would remain part of the benthic habitat. The diversity of the community would not change and associated finfish species would continue to graze on the encrusting organisms. The community would remain an active artificial reef. However, the plugging of wells and other reef in place decommissioning activities would still impact benthic communities as discussed above, since all the steps for removal except final removal from the water would still occur.

Proposed Action Analysis

As mentioned earlier, a majority of the seafloor of the Gulf of Mexico is soft-bottom sediments. Drilling activities would occur directly in these soft substrates; however, these routine activities would only affect a small portion of the substrate and benthic communities of the Gulf of Mexico. The CPA covers 268,922 km^2 (103,831 mi^2). Operations may affect soft-bottom benthic communities through drilling effluent discharges and produced-water discharges, blowouts, and oil spills. Of the small area affected, the impacts have been measured to reach only about 100-500 m (328-1,640 ft) from the production well.

For the CPA proposed action, 65-121 exploration/and 338-576 development wells are projected (**Table 3-2**). Cuttings from the wells would be released at the sea surface and dispersed in the water column, resulting in a widespread deposition on the seafloor (up to 1,000 m [3,280 ft] distance; CSA, 2006a). Deposition thickness would be patchy, but it should only accumulate a few centimeters to possibly a meter on the seafloor (beside the well) (CSA, 2004b and 2006a). Benthic organisms are anticipated to either vertically migrate through the depositional layers or immigrants would repopulate the smothered habitat. Altered community structure may occur as a result of the environmental changes, but this alteration would be limited to a few hundred meters from the well.

If any of these wells are proposed near a topographic feature, no discharges would take place within the feature's No Activity Zone. The drilling discharges would be shunted to within 10 m (33 ft) of the seafloor either within the 1,000-Meter Zone, 1-Mile Zone, 3-Mile Zone, or 4-Mile Zone (depending on the topographic feature) around the No Activity Zone (see **Chapter 2.3.1.3.1** for specifics). This procedure would essentially prevent the threat of large amounts of drilling effluents reaching the biota of a given topographic feature. It would, however, result in heavy layers of cuttings on the seafloor, which could smother underlying benthic communities and create turbid waters in a localized area near the well. Seafloor depositions have been measured to 1,000 m (3,280 ft) in a gradient of declining density with distance from the well (Kennicutt et al., 1996; CSA, 2006a). Benthic organisms may not be able to vertically migrate through the heavy depositional layers near the well, but it is anticipated that they would repopulate the areas through the reproduction and immigration of nearby stocks. Altered community structure may occur as a result of environmental changes, but this alteration would be limited to a few hundred meters from the well.

For the CPA proposed action, 32-44 production structures are projected. Between 23 and 32 structure removals using explosives are projected (**Table 3-2**). The explosive removals of platforms may impact the biota through suspended sediment, sediment redeposition and smothering, explosive shock, and loss of hard substrate habitat. Communities, however, are anticipated to recover. Turbidity impacts would be short lived, and many organisms are tolerant of short-term increases in turbidity. Repopulation of the area disturbed by burial and shock-wave effects would begin within 6 months to a year, although it may take several years for complete recovery (Rhodes and Germano, 1982; Neff et al., 2000; Newell et al., 1998). And although the hard substrate that provided structure for encrusting organisms that created an artificial reef habitat may be removed, the environment would return to its previous state as a soft-bottom infaunal community.

Summary and Conclusion

Although localized impacts to comparatively small areas of the soft-bottom benthic habitats would occur, the impacts would be on a relatively small area of the seafloor compared with the overall area of the seafloor of the CPA (268,922 km^2, 103,831 mi^2). The greatest impact is the alteration of benthic communities as a result of smothering, chemical toxicity, and substrate change. Communities that are

smothered by cuttings repopulate, and populations that are eliminated as a result of sediment toxicity or organic enrichment would be taken over by more tolerant species. The community alterations are not so much the introduction of a new benthic community as a shift in species dominance (Montagna and Harper, 1996). These localized impacts generally occur within a few hundred meters of platforms, and the greatest impacts are seen close to the platform. These patchy habitats within the Gulf of Mexico are probably not very different from the early successional communities that predominate throughout areas of the Gulf of Mexico that are frequently disturbed (Rabalais et al., 2002; Gaston et al., 1998; Diaz and Solow, 1999).

4.1.1.22.1.3. Impacts of Accidental Events

Background/Introduction

The majority of the seafloor of the Gulf of Mexico is comprised of soft substrate. The soft-bottom benthic communities of the CPA are described in **Chapter 4.1.1.22.1.1**. Any activity that may affect the soft-bottom communities would only impact a small portion of the overall area of the seafloor of the Gulf of Mexico. Because the soft-bottom substrate is ubiquitous throughout the Gulf of Mexico, there are no lease stipulations to avoid these communities. Other routine practices restrict detrimental activities that could cause undue harm to benthic habitats (e.g., discharge restrictions, debris regulations, NPDES permits).

This is an entirely new section to this Supplemental EIS, as soft-bottom benthic community impacts were not discussed in the Multisale EIS or the 2009-2012 Supplemental EIS. Various Internet sources and journal articles were examined to discover information regarding impacts of oil on soft-bottom benthic organisms. Sources investigated include literature published in journals and websites (NOAA, USEPA, and coastal universities).

Possible Modes of Exposure

Oil released to the environment as a result of an accidental event may impact soft-bottom benthic communities in several ways. Oil may be physically mixed into the water column from the sea surface, injected below the sea surface and travel with currents, dispersed in the water column, or sedimented to particles and sink to the seafloor. These scenarios and their possible impacts are discussed in the following sections.

An oil spill that occurs at the sea surface would result in a majority of the oil remaining at the sea surface. Lighter compounds in the oil may evaporate and some components of the oil may dissolve in the seawater. Evaporation allows the removal of the most toxic components of the oil, while dissolution may allow bioavailability of hydrocarbons to marine organisms for a brief period of time (Lewis and Aurand, 1997). Remnants of the oil may then emulsify with water or sediment to particles and fall to the seafloor.

A spill that occurs below the sea surface (at the rig, along the riser between the seafloor and sea surface, or through leak paths on the BOP/wellhead) would result in most of the released oil rising to the sea surface. All known reserves in the Gulf of Mexico have specific gravity characteristics that would preclude oil from sinking immediately after release at a blowout site. As discussed in Chapter 4.3.1.5.4 of the Multisale EIS, oil discharges that occur at the seafloor from a pipeline or loss of well control would rise in the water column, surfacing almost directly over the source location, thus not impacting sensitive deepwater communities. If the leak is deep in the water column and the oil is ejected under pressure, oil droplets may become entrained deep in the water column (Boehm and Fiest, 1982). The upward movement of the oil may be reduced if methane in the oil is dissolved at the high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). The large oil droplets would rise to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume or the injection of dispersants, may remain neutrally buoyant in the water column, creating a subsurface plume (Adcroft et al., 2010). Oil droplets less than 100 μm (0.004 in) in diameter may remain in the water column for several months (Joint Analysis Group, 2010a). Dispersed oil in the water column begins to biodegrade and may flocculate with particulate matter, promoting sinking of the particles.

Impacts that may occur to soft-bottom benthic communities as a result of a spill would depend on the type of spill, distance from the spill, and surrounding physical characteristics of the environment. As described above, most of the oil released from a spill would rise to the sea surface, therefore, reducing the

impact to benthic communities by direct oil exposure. However, small droplets of oil that are entrained in the water column for extended periods of time would migrate within the water column. Although these small oil droplets would not sink themselves, they may attach to suspended particles in the water column and then be deposited on the seafloor (McAuliffe et al., 1975). Exposure to subsea plumes, dispersed oil, or sedimented oil may result in impacts such as smothering, reduced recruitment success, reduced growth, toxicity to larvae, alteration of embryonic development, and altered community structure. These impacts are discussed in the following sections.

Surface Slick and Physical Mixing

Surface oil slicks can spread over a large area; however, the majority of the slick is comprised of a very thin surface layer of oil moved by winds and currents (Lewis and Aurand, 1997). The potential of surface oil slicks to affect benthic habitats is limited by its ability to mix into the water column. Soft-bottom benthic communities below 10-m (33-ft) water depth are protected from surface oil because of its lack of ability to mix with water (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Benthic organisms would not become physically coated or smothered by surface oil. However, if this surface oil makes its way into the water column through physical mixing, the use of dispersants, or sedimenting to particles in the water column, benthic communities may be impacted. These scenarios are discussed in later sections.

Disturbance of the sea surface by storms can mix surface oil into the water column, but the effects are generally limited to the upper 10 m (33 ft). Modeling exercises have indicated that oil may reach a depth of 20 m (66 ft). Yet at this depth, the spilled oil would be at concentrations several orders of magnitude lower than the amount shown to have an effect on marine organisms (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). Therefore, soft-bottom benthic communities located in shallow water have the potential to be fouled by oil that is floating on shallow water and mixes to the depth of the seafloor. Nearshore oil deposits that occur in sheltered areas, such as bays, may remain in the sediment and impact organisms for long periods. Oil in nearshore sediments was found in high concentrations 8 years following the *Exxon Valdez* spill (Dean and Jewett, 2001). Benthic communities located in deeper water would not be impacted by oil physically mixed into the water column. However, if dispersants are used, they would enable oil to mix into the water column and possibly impact organisms in deeper water. Dispersants are discussed later in this section.

Subsurface Plumes

A subsurface oil spill or plume has the potential to reach a soft-bottom benthic community and cause negative effects. Such impacts on the biota may have severe and long-lasting consequences, including loss of habitat and biodiversity; change in community structure; toxicity to larvae and embryos; and failed reproductive success.

A subsurface plume that contacts the seafloor may result in acute toxicity. The water accommodated fraction (WAF) or water soluble fraction (WSF) of oil that dissolves in water may be the most toxic to organisms, especially larvae and embryos in the water column or at the water sediment interface. Lethal effects for marine invertebrates have been reported at exposures between 0.10 ppm to 100 ppm WSF of oil (Suchanek, 1993). The WSF of petroleum hydrocarbons was reportedly highly toxic to the embryos of oysters and sea urchins, while sediment containing weathered fuel was not toxic to the same species (Beiras and Saco-Álvarez, 2006). Quahog clam embryos and larvae also experienced toxicity and deformation of several different crude oils at WSF concentrations between 0.10 ppm and 10 ppm (Byrne and Calder, 1977). An experiment indicated that the WSF of No. 2 fuel oil at a concentration of 5 ppm disrupted the cellular development of 270 out of 300 test organisms within 3 hours of exposure (Byrne, 1989). After 48 hours exposure, all of the test organisms died and the 48-hour LC_{50} (lethal concentration for 50 percent of the test population) was calculated to be 0.59 ppm (Byrne, 1989). Another experiment indicated that a WSF of 0.6 ppm and greater of No. 2 fuel oil depressed respiration, reduced mobility of sperm, interfered with cell fertilization and embryonic cleavage, and retarded larval development of sand dollar eggs (Nicol et al., 1977). Experiments that exposed sea urchin embryos to 10-30 ppm WSF of diesel oil for 15-45 days resulted in defective embryonic development and nonviable offspring (Vashchenko, 1980). Therefore, any dissolved petroleum hydrocarbon constituents that reach larval benthic organisms may cause acute toxicity and other developmental effects to this life stage.

Sublethal responses of marine invertebrates may result in population level changes (Suchanek, 1993). Such sublethal responses may occur at concentrations as low as 1-10 ppb (Hyland and Schneider, 1976). Sublethal impacts may include reduced feeding rates, reduced ability to detect food, ciliary inhibition, reduced movement, decreased aggression, and altered respiration (Suchanek, 1993).

The farther a subsea plume travels, the more physical and biological changes occur to the oil before it reaches benthic organisms. Oil becomes diluted as it physically mixes with the surrounding water, and some evaporation may occur from surface slicks. The most toxic compounds of oil are lost within the first 24 hours of a spill, leaving the heavier, less toxic compounds in the system (Ganning et al., 1984). Water currents could carry a plume to contact the seafloor directly but a likely scenario would be for the oil to adhere to other particles and precipitate to the seafloor, much like rainfall (ITOPF, 2007; Kingston et al., 1995). Oil also would reach the seafloor through consumption by plankton with excretion distributed over the seafloor (ITOPF, 2007). The longer and farther a subsea plume travels in the sea, the more dilute the oil will be (Vandermeulen, 1982; Tkalich and Chan, 2002). In addition, microbial degradation of the oil occurs in the water column, reducing toxicity (Hazen et al., 2010; McAuliffe et al., 1981b). The oil will move in the direction of prevailing currents (S.L. Ross Environmental Research Ltd., 1997) and although the oil will weather with the distance it travels, low levels of oil transported in subsea plumes will impact benthic communities. These mechanisms would result in a wide distribution of small amounts of oil. This oil would be in the process of biodegradation from bacterial action, which would continue on the seafloor, resulting in scattered microhabitats with an enriched carbon environment (Hazen et al., 2010).

Dispersed Oil

Chemically dispersed oil from a surface slick is not anticipated to result in lethal exposures to organisms on the seafloor. The chemical dispersion of oil may increase the weathering process and allow surface oil to penetrate to greater depths than physical mixing would permit, and the dispersed oil generally remains below the water's surface (McAuliffe et al., 1981b; Lewis and Aurand, 1997). However, reports on dispersant usage on surface plumes indicates that a majority of the dispersed oil remains in the top 10 m (33 ft) of the water column, with 60 percent of the oil in the top 2 m (6 ft) (McAuliffe et al., 1981a). Dispersant usage also reduces the oil's ability to stick to particles in the water column, slowing its rate of precipitation to the seafloor (McAuliffe et al., 1981a; Lewis and Aurand, 1997). However, the use of dispersant increases oil concentrations in the water column, ultimately leading to precipitation on the seafloor in some form (Whittle et al., 1982).

Field experiments designed to test dispersant use on oil spills reported dispersed oil concentrations between 1 and 3 ppm, 9 m (30 ft) below the sea surface, approximately 1 hour after treatment with dispersant (McAuliffe et al., 1981a and 1981b). Other studies indicated that dispersed oil concentrations were <1 ppm, 10 m (33 ft) below the sea surface (Lewis and Aurand, 1997). The above data indicate that the mixing depth of dispersed oil is less than the depths of the majority of the Gulf of Mexico. Oil plumes are carried by water currents; some of these currents may carry subsea plumes toward shore, reaching water shallow enough for the plume to impinge on the seafloor. Unless the source of the oil is in shallow water, the dispersed oil would likely be widely diffused by the time it reaches shallow water. Most currents, however, would move laterally along depth contours rather than approaching shore, since the shore acts as a barrier containing the water, much like a levee bounding a river; inshore water would have to be displaced for offshore currents to move shoreward. Therefore, most subsea oil plumes would continue in oceanic currents until the oil is deposited to the seafloor over time by flocculation (clumping), planktonic consumption and excretion, or bacterial biodegradation (eventually bacteria die and fall to the seafloor) (Hazen et al., 2010; ITOPF, 2007; Kingston et al., 1995). This pattern would result in distribution of tiny quantities of oil that are widely scattered over a very large area. This oil would be in the process of biodegradation from bacterial action, which would continue on the seafloor, resulting in scattered microhabitats with an enriched carbon environment (Hazen et al., 2010).

Any dispersed surface oil that may reach the benthic communities in the Gulf of Mexico would be expected to be at very low concentrations (<1 ppm) (McAuliffe et al., 1981a). Such concentrations may not be life threatening to adult stages but may harm larval or embryonic life stages of benthic organisms (Fucik et al., 1995; Suchanek, 1993; Beiras and Saco-Álvarez, 2006; Byrne, 1989). The LC_{50} for blue crab, white shrimp, and brown shrimp exposed to western and central Gulf of Mexico oil dispersed with

Corexit 9527 experienced toxicity of 50 percent of the test population at concentrations an order of magnitude greater than what is expected for dispersed oil in the environment (Fucik et al., 1995). Any dispersed oil in the water column that comes in contact with benthic organisms, however, may evoke short-term negative responses by the organisms or altered embryonic survival and development such as that discussed in the subsurface plumes section.

Dispersants that are used on oil below the sea surface can travel with currents through the water and may contact benthic organisms on the seafloor. It is possible that the dispersed oil could be concentrated enough to harm a benthic community near the oil's source. However, the longer the oil remains suspended in the water column traveling with currents, the more it would disperse. Weathering would also be accelerated and biological toxicity reduced (McAuliffe et al., 1981b). Although the use of subsea dispersants is a new technique and very little data are available on dispersion rates, it is anticipated that any oil that could reach the seafloor would be in low concentration based on surface slick dilution data (McAuliffe et al., 1981a; Lewis and Aurand, 1997). Therefore, impacts resulting from exposure to dispersed oil, except possibly for communities very close to applications, are anticipated to be sublethal.

Soft-bottom infaunal communities near the oil spill that are negatively impacted by direct contact with oil or dispersed oil may experience sublethal and/or lethal effects. Localized areas of lethal effects would be recolonized by populations from neighboring soft-bottom substrate once the oil in the sediment has been sufficiently reduced to support marine life (Sanders et al., 1980). This initial recolonization process may be fairly rapid, but full recovery may take up to 10 years, depending on the species present, substrate in the area, toxicity of oil spilled, concentration and dispersion of oil spilled, and surrounding environmental factors that may also affect recruitment (Kingston et al., 1995; Gómez Gesteira and Dauvin, 2000; Sanders et al., 1980; Conan, 1982). Opportunistic species would take advantage of the barren sediment, repopulating impacted areas first. These species may occur within the first recruitment cycle of the surrounding populations or from species immigration from surrounding stocks, and they may maintain a stronghold in the area until community succession proceeds (Rhodes and Germano, 1982; Sanders et al., 1980).

Sedimented Oil (Oil Adsorbed to Sediment)

Smaller suspended oil droplets could be carried to the seafloor as a result of oil droplets adhering to suspended particles in the water column. Smaller particles have a greater affinity for oil (Lewis and Aurand, 1997). Oil may also reach the seafloor through consumption by plankton with excretion distributed over the seafloor (ITOPF, 2007). Oiled sediment that settles to the seafloor may affect benthic organisms. It is anticipated that the greatest amount of sedimented oil would occur close to the spill, with lesser concentrations farther from the source. Studies after a spill that occurred at the Chevron Main Pass Block 41C Platform in the northern Gulf of Mexico revealed that the highest concentrations of oil in the sediment were close to the platform and that the oil settled to the seafloor within 5-10 mi (8-16 km) of the spill site (McAuliffe et al., 1975). Therefore, the benthic communities closest to the source of a spill may become smothered by the particles and exposed to toxic hydrocarbons.

Oiled sediment depositional impacts, however, are possible as a result of an oil spill and may smother nearby benthic species. Organisms that are physically smothered by sedimented oil, or the oil itself, may experience reduced respiration and inhibition of movement, and mobile organisms may experience additional weight or shearing forces form the sedimented oil (Suchanek, 1993). Barnacles, for example, are extremely tolerant to oil exposure but would die if smothered by it (Suchanek, 1993).

Locations closest to the oil spill would have elevated contaminant levels in sediments. Deposition of sedimented oil is anticipated to begin occurring within days or weeks of the spill and may be fairly deep (Ganning et al., 1984; Gómez Gesteira and Dauvin, 2000). Oily sand layers were reported to be 10 cm (4 in) deep on the seafloor near the *Amoco Cadiz* spill (Gómez Gesteira and Dauvin, 2000). Acute toxicity may occur near the spill, eliminating benthic communities. As the benthic species recolonize the area, there would be a reduced trophic diversity and an increase in opportunistic pollution tolerant species (Gaston et al., 1998).

Those species that can tolerate the disturbed or contaminated environment and can recruit rapidly would be the initial colonizers of the impacted area. Recolonization and immigration by organisms from neighboring soft-bottom substrate to the impacted areas would be expected to occur within a relatively short period of time. Initial repopulation from nearby stocks may begin with the following recruitment

event and be predominantly comprised of pioneering species, such as tube-dwelling polychaetes or oligochaetes (Rhodes and Germano, 1982). The contaminated or disturbed area would be initially dominated by small, opportunistic, subsurface deposit feeders that inhabit the sediment water interface and are more tolerant of contaminants (Gaston et al., 1998). Two pioneering Capitellid polychaetes in the Gulf of Mexico known to tolerate environmental stress are *Mediomastus californiensis* and *Notomastus latericeus*, and they would be the first to inhabit recovering areas (Gaston et al., 1998). Amphipods on the other hand, especially of the genus *Ampelisca*, are extremely sensitive to oil pollution and would not be found in the early recovery stages after hydrocarbon pollution (Gómez Gesteira and Dauvin, 2000). Full recovery would follow as later stages of successional communities overtake the opportunistic species (Rhodes and Germano, 1982), but the time it takes to reach a climax community may vary depending on the species and degree of impact. Initial recovery should be well advanced within a year following the deposition (Neff, 2005). Because some benthic communities in the northern Gulf of Mexico are permanently in early community successional stages due to frequent disturbances, full recovery may occur very quickly (Rabalais et al., 2002; Gaston et al., 1998; Diaz and Solow, 1999).

Experiments and field data indicate that benthic recovery will take approximately 1 year to occur. For example, a study of the recolonization and succession of subtidal macrobenthos in sediment contaminated with petroleum hydrocarbons indicated that recovery to pre-oiling conditions took 11 months (Lu and Wu, 2006). Initial colonization occurred within the first month of the study and polychaetes dominated the population (Lu and Wu, 2006). A crest after 3 months occurred with polychaetes being dominant, then at 6 months a peak occurred with bivalves dominating, followed by a decline in number of organisms and a leveling off of the community at 11 months (Lu and Wu, 2006). A similar time scale was observed in Corpus Christi Bay, Texas, where recovery from dredge material placement occurred after 1 year (Wilber et al., 2008). Recovery of benthic populations in soft subtidal environments, however, has been reported to take up to 5-10 years after oiling (Ganning et al., 1984; Gómez Gesteira and Dauvin, 2000). The overall recovery would depend on the extent of oiling, presence of recolonizers nearby, time of year for reproduction of those colonizers, currents and water circulation patterns, and the ability of the recolonizers to tolerate the sediment conditions (Ganning et al., 1984).

Certain species are more sensitive to oil than others. Crustaceans, for example, are very sensitive to oil and have disappeared from oiled environments and had slow returns to the oiled areas (Dean and Jewett, 2001; Gómez Gesteria and Dauvin, 2000). The amphipod, *Ampelisca* sp., which disappeared from some sediments after the *Amoco Cadiz* oil spill took 2 years to begin repopulating areas, as the sediments decreased in contamination (Gómez Gesteira and Dauvin, 2000). Polychaetes, on the other hand, are much less sensitive to oil pollution and may experience population booms in contaminated areas (Gómez Gesteira and Dauvin, 2000).

The benthic population may be altered following an oil spill, and the return to pre-spill conditions may take many years. Opportunistic species are usually the first to occupy contaminated sediments, especially the polychaete, *Capitella capitata* (Sanders et al., 1980). Some polychaetes have been reported to have positive responses to oiling where they have greater densities at oiled sites compared with oil-free sites (Dean and Jewett, 2001). Concentrations as low as 10 ppm may alter benthic community structure (Gómez Gesteira and Dauvin, 2000).

An alteration in the benthic trophic structure may impact food availability for fish and invertebrates. Burrowing polychaetes and subsurface deposit feeders are not important in the diets of the red drum and spotted sea trout, two commercially and recreationally important species in the Gulf of Mexico (Gaston et al., 1998). Therefore, an increase in opportunistic species would result in less available food for certain species of fish (Gaston et al., 1998). The small surface-dwelling opportunistic species, however, appear to be important in the diet of juvenile brown shrimp (McTigue and Zimmerman, 1998) and therefore may provide additional food sources for this species. Early stage successional communities, however, cannot store and regulate the nutritional energy that a later stage community can because the organisms are small and remain at the sediment surface, resulting in a less stable and productive food source for higher trophic levels (Diaz and Solow, 1999).

Oil may be persistent when deposited in soft-bottom habitats, and biodegradation rates may be slower than those in coarser sediments (Dean and Jewett, 2001; Whittle et al., 1982). The oil at the surface may be weathered by bacteria, but the oil that is buried may remain unchanged for long periods of time because oxygen is required to weather oil, and lower sediment layers may be anoxic (Whittle et al., 1982; Ganning et al., 1984). Infaunal benthic species may be very sensitive to the persistent oil in benthic

sediments that do not experience rapid biodegradation (Ganning et al., 1984). Oil that penetrates deep into the sediment can also cause anoxia and toxicity to the infaunal population as a result (Ganning et al., 1984). Minimum residence time for oil deposited in offshore sediments is estimated to be 3-4 years (Ganning et al., 1984; Moore, 1976).

Long-term or low-level exposure may also occur to benthic infauna exposed to oil adhered to sediment. Mesocosm experiments using long-term, low-level concentrations of No. 2 fuel oil indicate acute toxicity to meiofauna due to direct oil contact and sublethal effects from sedimented oil and byproducts of the decomposition of the sedimented oil (Frithsen et al., 1985). Long-term exposure to low levels of fuel oil was shown to affect recruitment success; meiofaunal population recovery took between 2 and 7 months (Frithsen et al., 1985). These types of impacts would be expected farther from the well where oil concentrations were diluted with distance.

Some oiled particles may become widely dispersed as they travel with currents while they settle out of suspension. Sedimented oil may travel great distances from the spill site and could be deposited 1-2 years following the spill (Suchanek, 1993). Settling rates are determined by size and weight of the particle, salinity, and turbulent mixing in the area (Poirier and Thiel, 1941; Bassin and Ichiye, 1977; Deleersbijder et al., 2006). Because particles would have different sinking rates, the oiled particles would be dispersed over a large area, most likely at sublethal or immeasurable levels. Studies conducted after the *Ixtoc* oil spill revealed that, although oil was measured on particles in the water column, measurable petroleum levels were not found in the underlying sediment (ERCO, 1982). Based on the settling rates and behavior of sedimented oil, the majority of organisms that may be exposed to sedimented oil are anticipated to experience low-level concentrations.

Research on oil spilled from the Chevron Main Pass Block 41C Platform into the Gulf of Mexico has indicated that oil in bottom sediments can weather rapidly, leaving only a small percentage of the oil in the sediments after a year (McAuliffe et al., 1975). Substantial weathering was noted 1 week and 1 month after the Chevron Main Pass spill and the oil remained in the top 1.5 in (3.8 cm) of the sediment. Benthic community fluctuations could not be correlated to the oil in the sediment from this oil spill and the numbers of brown and white shrimp and blue crabs in the area of the oil spill did not appear to decrease 3 months or 1 year after the spill (McAuliffe et al., 1975).

The toxicity of the oil is greatly reduced by the time it reaches the seafloor as a result of weathering in the water column (Ganning et al., 1984). The *Ixtoc* blowout flowed for 290 days and resulted in an estimated 120,000 metric tons of oil reaching the seafloor (Jernelöv and Lindén, 1981). Oil reached the seafloor in small droplets in the offshore waters, although some aggregates formed nearshore. The approximate concentration of oil on the seafloor was $1 g/m^2$, which is not high enough to cause substantial damage to a benthic ecosystem (Jernelöv and Lindén, 1981). Surface sediment samples collected mid- and post-spill did not reveal any hydrocarbons from the *Ixtoc* spill; however, hydrocarbons from this source were identified on suspended sediment in the water column (ERCO, 1982). These data show that the oil may take some time to reach the seafloor and when it does, it is widely dispersed and weathered.

As with the Chevron Main Pass spill, depressions in the benthic community during and following the *Ixtoc* spill could not be linked to the oil because hydrocarbons from the blowout were not present in sediment samples (ERCO, 1982). The benthic populations were depressed following the spill compared with pre-spill conditions; however, environmental evidence was not strong enough to separate oil impacts from natural variation or possible storm damage impacts (Tunnell et al., 1981). Oil may have been present in the sediment and affected benthic communities but weathered before sampling occurred, or oil in the water column may have affected species, but these possible factors were not measured (Rabalais, 1990).

Regardless of the speculations, field measurements indicate that the concentrations of oil that reached the seafloor were low even after uncontrolled flow for a long period of time, and the oil was vastly dispersed by the time it reached the seafloor. Inability to measure hydrocarbons in the sediment after the spill suggested that any oil that reached the seafloor had weathered rapidly. It is anticipated that similar dispersion of oil, rapid weathering, and resultant low-level, widespread concentrations of oil on the seafloor may be measured from similar blowouts.

Weathered oil is less toxic than freshly spilled oil because the remaining constituents are the larger, less bioavailable compounds (Ganning et al., 1984). The oil deposited on the seafloor is weathered from traveling in the water column and has lost a majority of its toxic compounds (Beiras and Saco-Álvarez, 2006). For example, amphipods, which are very sensitive to petroleum hydrocarbons, do not experience

the level of toxicity when exposed to weathered oil that they do to fresh oil (Gómez Gesteira and Dauvin, 2000). Therefore, the majority of the oil that is on the seafloor would most likely result in sublethal impacts rather than acute toxicity, except for oil that may be rapidly deposited on the seafloor near the source of the spill.

Blowout and Sedimentation

Oil or gas well blowouts are possible occurrences in the OCS. Benthic communities exposed to large amounts of resuspended sediments following a subsurface blowout could be subject to sediment suffocation and exposure to toxic contaminants. Sediment deposition may smother benthic organisms, decreasing gas exchange, increasing exposure to anaerobic sediment, and causing physical abrasion (Wilber et al., 2005). Should oil or condensate be present in the blowout flow, liquid hydrocarbons could be an added source of negative impact on the benthos.

In rare cases, a portion or the entire rig may sink to the seafloor as a result of a blowout. The benthic communities on the seafloor upon which the rig settles would be destroyed or smothered. A settling rig may suspend sediments, which may smother nearby benthic communities as the sediment is redeposited on the seafloor. The habitats beneath the rig may be permanently lost; however, the rig itself may become an artificial reef upon which epibenthic organisms may settle. The rig may add to the contaminants in the local area by leaking stores of fuel, oil, well treatment chemicals, and other toxic substances. The surrounding benthic communities that were smothered by sediment would repopulate from nearby stocks through spawning recruitment and immigration.

Soft-bottom infaunal communities that are smothered or lost would be recolonized by populations from neighboring soft-bottom substrate. Recolonization would begin with the next recruitment cycle of the surrounding populations or from species immigration from surrounding stocks and may maintain a stronghold in the area until community succession begins (Rhodes and Germano, 1982; Sanders et al., 1980). Repopulation and succession in a disturbed bay off coastal Texas occurred within a year (Wilber et al., 2008).

Response Activity Impacts

Oil-spill-response activity may also affect sessile benthic communities. Continued localized disturbance of soft-bottom communities may occur during oil-spill-response efforts. Anchors used to set booms to contain oil or vessel anchors in decontamination zones may affect infaunal communities in the response activity zone. Infaunal communities may be altered in the anchor scar, and deposition of suspended sediment may result from setting and resetting of anchors. Anchors may also destroy submerged vegetation, altering benthic habitat (Dean and Jewett, 2001). The disturbed benthic community should begin to repopulate from the surrounding communities during their next recruitment event and through immigration of organisms from surrounding stocks. Any decontamination activities, such as cleaning vessel hulls of oil, may also contaminate the sediments of the decontamination zone, as some oil may settle to the seabed, impacting the underlying benthic community.

If a blowout occurs at the seafloor, drilling muds (primarily barite) may be pumped into a well in order to “kill” it. If a kill is not successful, the mud (possibly tens of thousands of barrels) may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath heavy layers of the extruded drilling mud would be buried. Base fluids of drilling muds are designed to be low in toxicity and biodegradable in offshore marine sediments (Neff et al., 2000). However, as bacteria and fungi break down the drilling fluids, the sediments may be come anoxic (Neff et al., 2000). Benthic macrofaunal recovery would occur when drilling mud concentrations are reduced to levels that enable the sediment to become reoxygenated (Neff et al., 2000). Complete community recovery from drilling mud exposure may take 3-5 years, although microbial degradation of drilling fluids, followed by an influx of tolerant opportunistic species, is anticipated to begin almost immediately (Neff et al., 2000).

Proposed Action Analysis

A subsurface spill or plume may impact soft-bottom benthic communities. Oil or dispersed oil may cause lethal or sublethal impacts to benthic organisms where a plume may contact them. Impacts may include loss of habitat and biodiversity, contamination of substrate, change in community structure,

toxicity to larvae and embryos, and failed reproductive success. Sedimented oil or sedimentation as a result of a blowout would impact benthic organisms, although the greatest impact would be to those organisms closest to the spill. Communities farther from the spill may experience low-level exposure and possibly sublethal impacts. It is important to note that soft sediments cover a majority of the seafloor of the Gulf of Mexico and any impacts incurred, even lethal exposures, would not impact the overall population of soft-bottom benthic organisms that inhabit the seafloor of the Gulf of Mexico. Any local communities that are lost would be repopulated fairly rapidly (Neff, 2005). Those communities that are continuously in an early successional stage would reach their previous community composition rapidly, in as little as 1 year (Gaston et al., 1998).

Summary and Conclusion

Because of the small amount of proportional space that OCS activities occupy on the seafloor, only a very small portion of the seafloor of the Gulf of Mexico would experience lethal impacts as a result of blowouts, surface and subsurface oil spills, and the associated effects. The greatest impacts would be closest to the spill, and impacts would decrease with distance from the spill. Contact with spilled oil at a distance from the spill would likely cause sublethal to immeasurable effects to benthic organisms because the distance of activity would prevent contact with concentrated oil. Oil from a subsurface spill that reaches benthic communities would be primarily sublethal and impacts would be at the local community level. Any sedimentation and sedimented oil would also be at low concentrations by the time it reaches benthic communities far from the location of the spill, also resulting in sublethal impacts. Also, any local communities that are lost would be repopulated fairly rapidly (Neff, 2005). Although an oil spill may have some detrimental impacts, especially closest to the occurrence of the spill, the impacts may be no greater than natural biological fluctuations (Clark, 1982), and impacts would be to an extremely small portion of the overall Gulf of Mexico.

4.1.1.22.1.4. Cumulative Impacts

This cumulative analysis considers the effects of impact-producing factors related to soft bottoms of the Gulf of Mexico continental shelf. The proposed action plus those related to prior and future OCS lease sales are considered; in this discussion, these are referred to as “OCS-related” factors. Other impacting factors that may occur and adversely affect soft-bottom benthic communities include shipping operations, cable and pipeline laying, bottom trawling, hypoxia (low oxygen levels ≤2 ppm), and storm events. The vast majority of the Gulf of Mexico seabed is comprised of soft sediments and drilling is focused on these sediments, so the greatest number of impacts occurs on soft-bottom benthic environments. Specific OCS-related, impact-producing factors considered in the analysis are structure emplacement and removal, anchoring, discharges from well drilling, produced waters, pipeline emplacement, oil spills, blowouts, and operational discharges. Non-OCS-related impacts, including commercial fisheries, natural disturbances, anchoring by recreational boats, and other non-OCS commercial vessels, as well as spillage from import tankering, all have the potential to damage soft-bottom benthic communities.

There are no BOEMRE stipulations that require avoidance of soft-bottom benthic communities because they are so ubiquitous throughout the seafloor of the Gulf of Mexico; most of the 268,922 km^2 (103,831 mi^2) of the CPA are soft mud bottoms; they are the substrate upon which well drilling occurs. It is important to note, however, that because the soft-bottom benthic communities comprise a majority of the seafloor of the Gulf of Mexico, impacts are not detrimental to the overall population of these habitats across the Gulf of Mexico. Also, because a large portion of the seafloor is subject to natural fluctuations and physical disturbances (such as storms and yearly hypoxic events), a permanent early successional community occupies much of the seafloor and enables rapid recovery of disturbed areas.

Severe physical damage may occur to soft-bottom sediments and the associated benthic communities as a result of non-OCS activities. It is assumed infauna associated with soft-bottom sediments of the CPA are well adapted to natural disturbances such as turbidity and storms. However, human disturbance, such as trawling or non-OCS activity oil spills, could cause severe damage to infauna, possibly leading to changes of physical integrity, species diversity, or biological productivity. If such events were to occur, recovery to pre-impact conditions could take approximately a year (Lu and Wu, 2006; Neff, 2005), with the overall recovery time depending on the extent of oiling, presence of recolonizers nearby, time of year

for reproduction of those colonizers, currents and water circulation patterns, and the ability of the recolonizers to tolerate the sediment conditions (Ganning et al., 1984). Recovery of benthic populations in soft subtidal environments, however, have been reported to take up to 5-10 years after oiling (Ganning et al., 1984; Gómez Gesteira and Dauvin, 2000). However, because some benthic communities in the northern Gulf of Mexico are permanently in early community successional stages due to frequent disturbances, full recovery may occur very quickly (Rabalais et al., 2002; Gaston et al., 1998; Diaz and Solow, 1999).

Non-OCS activities have a greater potential to affect the soft-bottom communities of the region than BOEMRE-regulated activities. Natural events such as storms, extreme weather, and fluctuations of environmental conditions may impact soft-bottom infaunal communities. Soft-bottom communities occur from the shoreline into the deep waters of the Gulf of Mexico. Storms can physically affect shallow bottom environments, causing an increase in sedimentation, burial of organisms by sediment, a rapid change in salinity or dissolved oxygen levels, storm surge scouring, remobilization of contaminants in the sediment, and abrasion and clogging of gills as a result of turbidity (Engle et al., 2008). Storms have also been shown to uproot benthic organisms from the sediment and suspend organisms in the water column (Dobbs and Vozarik, 1983). Large storms may devastate infaunal populations; for example, 2 months after Hurricane Katrina a significant decrease in the number of species, species diversity, and species density occurred in coastal waters off Louisiana, Mississippi, and Alabama (Engle et al., 2008). Such impacts may be devastating to a benthic community.

Hypoxic conditions of inconsistent intensities and ranges also occur annually in a band that stretches along the Louisiana-Texas shelf each summer (Rabalais et al., 2002). The dissolved oxygen levels in the Gulf of Mexico hypoxic zone are less than 2 parts per million (ppm). Such low concentrations are lethal to many benthic organisms and may result in the loss of some benthic populations. Recolonization of devastated areas by populations from unaffected neighboring soft-bottom substrate would be expected to occur within a relatively short period of time (Dubois et al., 2009; Thistle, 1981).

Recreational boating, fishing, and import tankering may have limited impact on soft-bottom communities. Ships anchoring near major shipping fairways of the CPA or recreational fishing boats setting anchor would impact bottom habitats. Anchor placement may crush and eliminate infauna in the footprint of the anchor.

Damage resulting from commercial fishing, especially bottom trawling, may have a severe impact on soft-bottom benthic communities. Bottom trawling in the Gulf of Mexico primarily targets shrimp from nearshore waters to depths of approximately 90 m (295 ft) (NRC, 2002), which are the depths where the greatest trawling impacts are anticipated. Studies have indicated that trawled seafloor has reduced species diversity compared with untrawled seafloor (McConnaughey et al., 2000). Trawl trails may scour sediment, killing infauna, and epifaunal organisms may be physically removed (Engel and Kvitek, 1998). Trawling also contributes regularly to turbidity, as nets drag the seafloor, leaving trails of suspended sediment. Repetitive disturbance by trawling activity may lead to a community dominated by opportunistic species (Engel and Kvitek, 1998). Recovery from the passing of a trawl net would begin to occur with the following reproduction cycle of surrounding benthic communities (Rhodes and Germano, 1982), but populations may be severely impacted by repetitive trawling activity (Engel and Kvitek, 1998).

Structure placement and anchor damage from support boats and ships, floating drilling units, and pipeline-laying vessels are oil and gas OCS-related threats that disturb areas of the seafloor. The size of the areas affected by chains associated with anchors and pipeline-laying barges would depend on the water depth, chain length, sizes of anchor and chain, method of placement, wind, and current (Lissner et al., 1991). Anchor damage could result in the crushing and smothering of infauna. Anchoring often destroys a wide swath of habitat by being dragged over the seafloor or by the vessel swinging at anchor, causing the anchor chain to drag over the seafloor (Lissner et al., 1991). Damage to infauna as a result of anchoring may take approximately 1 year to recover, depending on the reproductive cycle and immigration of surrounding communities (Rhodes and Germano, 1982).

Both explosive and nonexplosive structure-removal operations disturb the seafloor; however, they are not expected to affect soft-bottom communities because many sessile benthic organisms are known to resist the concussive force of structure-removal-type blasts (O'Keeffe and Young, 1984). O'Keeffe and Young (1984) also noted ". . . no damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods." Impacts to invertebrates are anticipated to be minimal as they do not have air bladders inside their bodies that may burst with explosions, as some fish do (Schroeder and Love, 2004).

Routine discharges of drilling muds and cuttings by oil and gas operations could affect biological communities and organisms through a variety of mechanisms, including the smothering of organisms through deposition or less obvious sublethal toxic effects (impacts to growth and reproduction). Smothering of infauna by drilling discharges may be one of the greatest impacts to localized communities near a well, especially one that has shunted its cuttings to the seafloor to protect surrounding sensitive features. The heaviest concentrations of well cuttings and drilling fluids, for both water-based and synthetic-based drilling muds, have been reported within 100 m (328 ft) of wells and are shown to decrease beyond that distance (CSA, 2004b; Kennicutt et al., 1996). Although impacts are locally drastic, cumulative impacts over the seafloor of the Gulf of Mexico are anticipated to be very small, as such comparatively small areas are affected.

Produced waters from petroleum operations are not likely to have a great impact on soft-bottom communities. Produced waters are rapidly diluted and impacts are generally only observed within proximity of the discharge point, and acute toxicity that may result from produced waters occurs "within the immediate mixing zone around a production platform" (Gittings et al., 1992b; Holdway, 2002). There have been no reported impacts to marine organisms or sediment contamination beyond 100 m (328 ft) of the produced-water discharge (Neff and Sauer, 1991; Trefry et al., 1995). Therefore, impacts to infauna are anticipated to be localized and only affect a small portion of the entire seafloor of the Gulf of Mexico.

Traditional pipeline-laying barges (as opposed to dynamically positioned barges) affect more seafloor than other anchoring impacts. These barges typically use an array of 8-12 anchors weighing about 4,500 kg (10,000 lb) each. While the large anchors crush organisms in their footprint, a much larger area is affected by anchor cable sweep as the barge is pulled forward to lay the pipeline by reeling-in forward cables and reeling-out aft cables. The anchors are reset repeatedly to forward positions to allow the barge to "crawl" forward. In this way, the anchor sweep scours parallel paths on each side of the vessel where the cables touch the seafloor. The width of the scoured paths varies with water depth (deeper water equals longer cables) and may be as much as 1,500 m (5,000 ft) to each side (only a portion of the cable adjacent to the anchor touches the seafloor). Another major impact of the process is pipeline burial. In waters ≤60 m (200 ft), burial of pipelines is required. This involves trenching up to 3.3 m (10 ft) deep in the seafloor from a water depth of ≤60 m (200 ft) to shore. This is a severe disturbance of the trenched area and creates a large turbidity plume. Resuspended sediments can cause obstruction of filter-feeding mechanisms of sedentary organisms and gills of fishes. Adverse impacts from resuspended sediments would be temporary, primarily sublethal in nature, and the effects would be limited to areas in the vicinity of the barge. Impacts may include "changes in respiration rate, abrasion and puncturing of structures, reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth or development, abnormal larval development, or reduced response to physical stimulus" (Anchor Environmental CA. L.P., 2003).

Surface oil slicks released offshore can be moved toward shore by winds, but oil mixed into the water column is moved by water currents, which do not generally travel toward shore (Pond and Pickard, 1983). Surface oil spills and dispersed oil released from tankers may impact shallow, nearshore benthic communities. Disturbance of the sea surface by storms can mix surface oil 10-20 m (33-66 ft) into the water column (Lange, 1985; McAuliffe et al., 1975 and 1981a; Tkalich and Chan, 2002). This may result in direct oil contact for shallow nearshore benthic communities. Direct oiling or exposure to water soluble fractions of oil may result in lethal impacts to organisms (Suchanek, 1993; Beiras and Saco-Álvarez, 2006; Byrne, 1989) or impaired embryonic development (Byrne and Calder, 1977; Nicol et al., 1977; Vashchenko, 1980). Benthic communities farther offshore, in deeper water, would be protected from direct physical contact of surface oil by depth below the sea surface. Any dispersed surface oil from a tanker or rig spill that may reach the benthic communities on the seafloor of the Gulf of Mexico at a depth greater than 10 m (33 ft) would be expected to be at very low concentrations (<1 ppm) (McAuliffe et al., 1981a and 1981b; Lewis and Aurand, 1997). Such concentrations may not be life threatening to adult stages, but they may harm larval or embryonic life stages of benthic organisms (Fucik et al., 1995; Suchanek, 1993; Beiras and Saco-Álvarez, 2006; Byrne, 1989).

Potential blowouts may impact the biota of the soft-bottom benthic communities. If any blowouts from wells occur, the suspended sediments should settle out of the water column fairly quickly, locally smothering benthic organisms near the well. Any oil that becomes entrained in a subsurface plume would be dispersed as it travels in the water column (Vandermuelen, 1982; Tkalich and Chan, 2002). Subsea oil plumes near the seafloor would pass over smooth soft bottom, continuing the processes of diffusion and

biodegradation. These plumes would continue to be dispersed over a wide area in low concentrations with sublethal to immeasurable effect. If concentrated oil were to contact the soft-bottom communities directly, the impacts may include lethal effects with loss of habitat and biodiversity, contamination of substrate, change in community structure, and failed reproductive success. Damage to infauna as a result of subsurface plume exposure may take approximately 1 year to recover, depending on the reproductive cycle and immigration of surrounding communities (Rhodes and Germano, 1982). A recent report documents damage to a deepwater coral community 7 mi (11 km) southwest of the blowout. Soft bottoms in this area likely received oil also, but they would not be expected to catch as much oil as the benthic communities with greater relief above the seafloor (USDOI, BOEMRE, 2010j).

It was estimated that 26 percent of the released oil from the DWH event remains in the environment as oil on or just below the water surface as a light sheen or tarballs, oil that was washed ashore or collected from the shore, and oil that is in the sediments (Lubchenco et al., 2010). This residual oil has been degrading over time. The greatest concentrations are expected to be near the wellhead and to decrease with distance from the source. Evidence shows that gas and oil from the DWH event in the water column has rapidly deteriorated (Hazen et al., 2010).

The cumulative impact to soft bottoms of possible future oil spills, along with the DWH event, is anticipated to be small. The limited data currently available on the impacts of the DWH event make it difficult to define impacts to the soft-bottom communities in the CPA. It appears some impacts have occurred to corals within 7 mi (11 km) of the well, and it is anticipated that the soft-bottom communities in the area were impacted as well but with a lower impact because smooth, flat seafloor would allow the oil plume to pass unimpeded. Water column sampling, however, indicated that concentrations of total petroleum hydrocarbons in the water column were less than 0.5 ppm, 40 and 45 nmi (74 and 83 km; 46 and 52 mi) northeast of the well (Haddad and Murawski, 2010). Therefore, the acute impacts of any large-scale blowout would likely be limited in scale and any additive impacts of several blowouts should have acute effects in only small areas, with possible sublethal impacts occurring over a larger area. However, the locally impacted seafloor would be very small compared with the overall size of the seafloor of the CPA (268,922 km^2; 103,831 mi^2) and would not impact the overall infaunal population.

Summary and Conclusion

Non-OCS activities that may occur on soft-bottom benthic substrate include recreational boating and fishing, import tankering, and natural events such as extreme weather conditions, and extreme fluctuations of environmental conditions. These activities could cause temporary damage to soft-bottom communities. Ships and fishermen anchoring on soft bottoms may crush and smother underlying organisms. During severe storms, such as hurricanes, large waves may stir bottom sediments, which cause scouring, remobilization of contaminants in the sediment, abrasion and clogging of gills as a result of turbidity, uprooting benthic organisms from the sediment, and an overall result in decreased species diversity (Engle et al., 2008; Dobbs and Vozarik, 1983). Yearly hypoxic events may eliminate many species from benthic populations over a wide area covering most of the CPA and part of the WPA continental shelf (Rabalais et al., 2002).

Impacts from routine activities of OCS oil and gas operations include anchoring, structure emplacement and removal, pipeline emplacement, drilling discharges, and discharges of produced waters. In addition, accidental subsea oil spills or blowouts associated with OCS activities can cause damage to infaunal communities. Long-term OCS activities are not expected to adversely impact the entire soft-bottom environment because the local impacted areas are extremely small compared with the entire seafloor of the Gulf of Mexico.

Impacts from blowouts, pipeline emplacement, muds and cuttings discharges, other operational discharges, and structure removals may have local devastating impacts but the cumulative effect on the overall seafloor and infaunal communities on the Gulf of Mexico would be very small. Soft-bottom benthic communities are ubiquitous throughout and often remain in an early successional stage due to natural fluctuation, and therefore, the activities of OCS production of oil and gas would not cause additional severe cumulative impacts.

The incremental contribution of the proposed action to the cumulative impact is expected to be slight, with possible impacts from physical disturbance of the bottom, discharges of drilling muds and cuttings, other OCS discharges, structure removals, and oil spills. Negative impacts, however, are small compared

with the overall size and ubiquitous composition of the soft-bottom benthic communities in the Gulf of Mexico.

4.1.1.22.2. Diamondback Terrapins

A description of diamondback terrapins as a resource has not been included in previous NEPA evaluations conducted by the BOEMRE Gulf of Mexico Region. Therefore, there is no prior discussion in the Multisale EIS or the 2009-2012 Supplemental EIS upon which to tier this information.

4.1.1.22.2.1. Description of the Affected Environment

Diamondback terrapins occur in 16 states along the Atlantic and Gulf Coasts; the coastline of Florida represents approximately 20 percent of their entire range (Butler et al., 2006). The one subspecies of terrapin that occurs in the CPA and that is a Federal species of concern is the Mississippi diamondback terrapin (*Malaclemys terrapin pileata*). The Mississippi diamondback terrapin (listed November 15, 1994) has a range that includes Louisiana, Mississippi, Alabama, Georgia, and Florida (USDOI, FWS, 2010b).

Terrapins inhabit brackish waters including coastal marshes, tidal flats, creeks, and lagoons behind barrier beaches (Hogan, 2003). Juveniles spend the first years of their life under mats of tidal wrack and flotsam. Terrapins meet the osmotic challenges of a saline environment with several behavioral, physiological, and anatomical adaptations (U.S. Dept. of the Army, COE, 2002b). Their diet consists of fish, snails, worms, clams, crabs, and marsh plants (Cagle, 1952).

Female Florida terrapins on the east coast reach sexual maturity at a plastron length of 135 mm (5 in) or 4-5 years of age; male Florida terrapins mature at 95 mm (4 in) about age 2-3 years (Butler et al., 2006). Reproductive activities vary throughout the terrapin range. Courtship and mating occur in March and April, and the nesting season extends through July (U.S. Dept. of the Army, COE, 2002b). Terrapins nest on dunes, beaches, sandy edges of marshes, islands, and dike roads (Roosenburg, 1994). The common factor for proper egg development is sandy soil, which does not clog eggshell pores, thus allowing sufficient gas exchange between the developing embryo and the environment (Roosenburg, 1994). Nesting occurs primarily in the daytime during high tide on high sand dunes with gentle slopes and minimal vegetation (Burger, 1977). Clutch size ranges from 4 to 22 eggs, and incubation time ranges from 61 to 104 days (Butler et al., 2006; Burger, 1977). Female terrapins may nest 2-3 times in the same nesting season. Gender determination is temperature-dependent. Hatching occurs from August through October in northern populations (Burger, 1977).

Severely depleted by commercial harvest for food a century ago, diamondback terrapins are currently threatened by drowning in crab pots, development of shoreline habitats and nesting beaches, predation of nests and adults, boat strikes, and road mortality (Butler et al., 2006). Spending most of their lives at the aquatic-terrestrial boundary in estuaries, terrapins are susceptible to habitat destruction from cleanup efforts, as well as direct catastrophic oil contact; however, most impacts cannot be quantified at this time. Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. The actual impacts of these storms on the animals in the Gulf and the listed species have not yet been determined and, for the most part, may remain very difficult to quantify. However, some impacts, such as loss of beach habitat, are known to have occurred and would impact terrapin populations that would have used those areas for nesting beaches.

The DWH event and associated oil spill has impacted the turtle community in the GOM. Impacts can be either direct (mortality or injury) or indirect (e.g., reduced prey availability); however, most impacts cannot be quantified at this time. The *Deepwater Horizon* Unified Command reports daily fish and wildlife collection reports that include turtles; this can be found at http://www.restorethegulf.gov/.

As of October 14, 2010, two other reptiles have been collected alive and one has been collected dead (RestoreTheGulf.gov, 2010f). As data continue to be gathered and impact assessments completed, a better characterization of the full scope of impacts to the terrapin populations in the GOM from the DWH event will be available.

4.1.1.22.2.2. Impacts of Routine Events

Background/Introduction

The major impact-producing factors resulting from the routine activities associated with the CPA proposed action that may affect the Mississippi diamondback terrapin (*Malaclemys terrapin pileata*) include beach trash and debris and efforts undertaken for the removal of marine debris or for beach restoration.

Proposed Action Analysis

Mississippi diamondback terrapins spend most of their lives at the aquatic-terrestrial boundary in estuaries. Terrapins are susceptible to habitat destruction from cleanup efforts; however, most impacts cannot be quantified at this time. Nests can also be disturbed or destroyed by cleanup efforts.

Habitat destruction, road construction, and drowning in crab traps are the most recent threats to diamondback terrapins. In the 1800's, populations declined due to overharvesting for meat (Hogan, 2003). Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to response efforts could drastically affect future population levels and reproduction. Characteristics of terrapin life history render this species especially vulnerable to overfishing and habitat loss. These characteristics include low reproductive rates, low survivorship, limited population movements, and nest site philopatry.

The major routine impact-producing factors associated with the CPA proposed action that may affect terrapins include beach trash and debris and efforts undertaken for the removal of marine debris or for beach restoration. Terrapins may mistakenly consume trash and debris or may become entangled in debris. The proposed action is expected to contribute negligible marine debris or disruption to terrapin habitat. Unless properly regulated, personnel removing marine debris may temporarily disturb terrapins or trample nesting sites. Due to the extended distance from shore, impacts associated with activities occurring in the OCS are not expected to impact terrapins or their habitat.

Little or no damage is expected to the physical integrity, species diversity, or biological productivity of terrapin habitat as a result of the CPA proposed action.

Summary and Conclusion

Impacts from routine activities resulting from the CPA proposed action are possible but unlikely. Because of the greatly improved handling of waste and trash by industry and the annual awareness training required by the marine debris mitigations, the amount of plastics in the ocean is decreasing, thus minimizing the devastating effects on offshore and coastal marine life. The routine activities of the CPA proposed action are unlikely to have significant adverse effects on the size and recovery of any terrapin species or population in the GOM.

4.1.1.22.2.3. Impacts of Accidental Events

Background/Introduction

The major impact-producing factors resulting from the accidental activities associated with the CPA proposed action that may affect the Mississippi diamondback terrapin (*Malaclemys terrapin pileata*) include offshore and coastal oil spills and spill-response activities.

Proposed Action Analysis

Spending most of their lives at the aquatic-terrestrial boundary in estuaries, terrapins are susceptible to habitat destruction from cleanup efforts, as well as direct catastrophic oil contact; however, most impacts cannot be quantified at this time. Even after the oil is no longer visible, terrapins may still be exposed while they forage in the salt marshes lining the edges of estuaries where oil may have accumulated under the sediments and within the food chain. Nests can also be disturbed or destroyed by cleanup efforts. Chronic (longer-term lethal or sublethal oil-related injuries) effects from oil contact may persist through the generations, potentially reducing population levels.

Habitat destruction, road construction, and drowning in crab traps are the most recent threats to diamondback terrapins. In the 1800's, populations declined due to overharvesting for meat (Hogan, 2003). Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to a catastrophic spill and response efforts could drastically affect future population levels and reproduction. Characteristics of terrapin life history render this species especially vulnerable to overfishing and habitat loss. These characteristics include low reproductive rates, low survivorship, limited population movements, and nest site philopatry.

The DWH event and associated oil spill has impacted the turtle community in the GOM. Impacts can be either direct (mortality or injury) or indirect (e.g., reduced prey availability); however, most impacts cannot be quantified at this time. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected marine mammal environment. The *Deepwater Horizon* Unified Command reports daily fish and wildlife collection reports that include turtles; this can be found at http://www.restorethegulf.gov/.

Summary and Conclusion

Habitat destruction, road construction, and drowning in crab traps are the most recent threats to diamondback terrapins. In the 1800's, populations declined due to overharvesting for meat (Hogan, 2003). Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to a catastrophic spill and response efforts could drastically affect future population levels and reproduction. However, there is not expected to be a significant increase to infrastructure, and the probability of a spill large enough to impact the diamondback terrapins or their habitat is low with the CPA proposed action.

No substantial information was found at this time that would alter the overall conclusion that accidental impacts on diamondback terrapins associated with the CPA proposed action would be minimal.

4.1.1.22.2.4. Cumulative Impacts

Background/Introduction

The major impact-producing factors resulting from the cumulative activities associated with the CPA proposed action that may affect the Mississippi diamondback terrapin (*Malaclemys terrapin pileata*) include oil spills and spill-response activities, alteration and reduction of habitat, predation and competition, and consumption of trash and debris.

Proposed Action Analysis

Most proposed action-related spills, as well as oil spills stemming from import tankering and prior and future lease sales, are not expected to contact terrapins or their habitats. Cumulative activities posing the greatest potential harm to terrapins are non-OCS factors (i.e., coastal spills) and natural catastrophes (i.e., hurricanes and tropical storms), which, in combination, could potentially deplete some terrapin populations to unsustainable levels. The expected incremental contribution of the CPA proposed action to the cumulative impacts is expected to be minimal.

Spending most of their lives within their limited home ranges at the aquatic-terrestrial boundary in estuaries, terrapins are susceptible to habitat destruction from cleanup efforts, as well as direct catastrophic oil contact; however, most impacts cannot be quantified at this time. Even after the oil is no longer visible, terrapins may still be exposed while they forage in the salt marshes lining the edges of estuaries where oil may have accumulated under the sediments and within the food chain (Roosenburg et al., 1999). Nests can also be disturbed or destroyed by cleanup efforts.

Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to response efforts could drastically affect future population levels and reproduction. Characteristics of terrapin life history render this species especially vulnerable to overfishing and habitat loss. These characteristics include low reproductive rates, low survivorship, limited population movements, and nest site philopatry.

The DWH event and associated oil spill has impacted the turtle community in the GOM. Impacts can be either direct (mortality or injury) or indirect (e.g., reduced prey availability); however, most impacts

cannot be quantified at this time. The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup activities on the affected marine mammal environment. The *Deepwater Horizon* Unified Command reports daily fish and wildlife collection reports that include turtles; this can be found at http://www.restorethegulf.gov/.

Summary and Conclusion

The major impact-producing factors resulting from the cumulative activities associated with the CPA proposed action that may affect the diamondback terrapin include oil spills and spill-response activities, alteration and reduction of habitat, predation and competition, and consumption of trash and debris. Due to the extended distance from shore, impacts associated with activities occurring in the OCS are not expected to impact terrapins or their habitat. No substantial new information was found at this time that would alter the overall conclusion that cumulative impacts on diamondback terrapins associated with the CPA proposed action is expected to be minimal.

4.1.2. Alternative B—The Proposed Action Excluding the Unleased Blocks Near Biologically Sensitive Topographic Features

Description of the Alternative

Alternative B differs from Alternative A (the proposed action) by not offering blocks that are possibly affected by the proposed Topographic Features Stipulation (**Chapter 2.3.1.3.1; Figure 2-1**). All of the assumptions (including the seven other potential mitigating measures) and estimates are the same as for the proposed action (Alternative A). A description of Alternative A is presented in **Chapter 2.3.1.1**.

Effects of the Alternative

The following analyses are based on the scenario for the CPA proposed action (Alternative A). The scenario provides assumptions and estimates on the amounts, locations, and timing for OCS exploration, development, and production operations and facilities, both offshore and onshore. These are estimates only and not predictions of what would happen as a result of holding the proposed lease sale. A detailed discussion of the scenario and related impact-producing factors is presented in **Chapter 3.1**.

The analyses of impacts to the various resources under Alternative B are very similar to those for Alternative A. The reader should refer to the appropriate discussions under Alternative A for additional and more detailed information regarding impact-producing factors and their expected effects on the various resources. Impacts under Alternative B are expected to be the same as the proposed action in the CPA (**Chapter 4.1**) for the following resources:

— Air Quality
— Water Quality
— Coastal Barrier Beaches and Associated Dunes
— Wetlands
— Seagrass
— Live Bottoms (Pinnacle Trend and Low Relief)
— Sargassum
— Chemosynthetic and Nonchemosynthetic Deepwater Benthic Communities
— Marine Mammals
— Sea Turtles
— Alabama, Choctawhatchee, St. Andrew and Perdido Key Beach Mice
— Coastal and Marine Birds
— Gulf Sturgeon
— Fish Resources and Essential Fish Habitat
— Commercial Fishing
— Recreational Fishing
— Recreational Resources
— Archaeological Resources
— Human Resources and Land Use
— Soft Bottoms
— Diamondback Terrapins

The impacts to some Gulf of Mexico resources under Alternative B would be different from the impacts expected under the proposed action. These impacts are described below.

Impacts on Topographic Features

The sources and severity of impacts associated with this alternative are those sale-related activities discussed for the proposed action. The potential impact-producing factors to the topographic features of the CPA are anchoring and structure emplacement, effluent discharge, blowouts, oil spills, and structure removal. A more detailed discussion of these potential impact-producing factors is presented in **Chapter 3.**

Of the 16 topographic features of the CPA, 15 are located within water depths less than 200 m (656 ft). Geyer Bank is located in water depths of 190-210 m (623-689 ft). These features occupy a very small portion of the entire area. Of the potential impact-producing factors that may affect the topographic features, anchoring, structure emplacement, and structure removal would be eliminated by the adoption of this alternative. Effluent discharge and blowouts would not be a threat to the topographic features because blocks near enough to the banks for these events to have an impact on the biota of the banks would have been excluded from leasing under this alternative. Thus, the only impact-producing factor remaining from operations in blocks included in this alternative (i.e., those blocks not excluded by this alternative) is an oil spill. The potential impacts from oil spills are summarized below and are discussed further in **Chapter 3.2.1**.

A subsurface spill would have to come into contact with a biologically sensitive feature to have an impact. A subsurface spill is expected to rise to the surface, and any oil remaining at depth would be swept clear of the banks by currents moving around the banks (Rezak et al., 1983). Deepwater subsurface spills may travel along the sea bottom or in the water column for some distance before rising to the surface. The fact that the topographic features are widely dispersed in the CPA, combined with the random nature of spill events, would serve to limit the likelihood of a spill occurring proximate to a topographic feature. Chapter 4.3.1.8 of the Multisale EIS discussed the risk of spills interacting with topographic features in more detail. The currents that move around the banks would likely steer any spilled oil around the banks rather than directly upon them, lessening impact severity. In the unlikely event that oil from a subsurface spill would reach the biota of a topographic feature, the effects would be primarily sublethal for most of the adult sessile biota. Lethal effects would probably be limited to a few coral colonies (CSA, 1992b and 1994). It is anticipated that recovery from a mostly sublethal exposure would occur within a period of 2 years. In the unlikely event that oil from a subsurface spill contacted a coral-covered area, the areal extent of coral mortality would be limited, but long-lasting sublethal effects may be incurred by organisms surviving the initial effects of a spill (Jackson et al., 1989). Indeed, the stress resulting from the oiling of reef coral colonies could affect their resilience to natural disturbances (e.g., elevated water temperature and diseases) and may hamper their ability to reproduce. A complete recovery of such an affected area could take in excess of 10 years.

Cumulative Impacts

With the exception of the topographic features, the cumulative impacts of Alternative B on the environmental and socioeconomic resources of the Gulf of Mexico would be identical to Alternative A. The incremental contribution of the proposed action to the cumulative impacts on topographic features is expected to be slight, and negative impacts should be restricted by the implementation of the Topographic Features Stipulation and site-specific mitigations, the depths of the features, and water currents in the topographic feature area.

Summary and Conclusion

Alternative B, if adopted, would prevent any oil and gas activity whatsoever in the blocks containing topographic features; thus, it would eliminate any potential direct impacts to the biota of those blocks from oil and gas activities, which otherwise would be conducted within the blocks. In the unlikely event that oil from a subsurface spill contacts the biota of a topographic feature, the effects would be localized and primarily sublethal for most of the adult sessile biota. Some lethal effects would probably occur upon oil contact to coral colonies.

4.1.3. Alternative C—The Proposed Action Excluding Unleased Blocks within 15 Miles of the Baldwin County, Alabama, Coast

Description of the Alternative

Alternative C differs from Alternative A (the proposed action) by not offering any unleased blocks within 15 mi (24 km) of the Baldwin County, Alabama, coast. All the assumptions (including potential mitigating measures) and estimates are the same as those under Alternative A (**Chapters 2.3.1.**). A description of Alternative A is presented in **Chapter 2.3.1.1**.

Effects of the Alternative

The following analyses are based on the scenario for the CPA proposed action (Alternative A). A detailed discussion of the scenario and related impact-producing factors is present in **Chapter 3.**

The analyses of impacts to the various resources under Alternative C are very similar to those for Alternative A. The reader should refer to the appropriate discussions under Alternative A for additional and more detailed information regarding impact-producing factors and their effects on the various resources. Impacts are expected to be the same as those estimated under the proposed action in the CPA (**Chapter 4.1**) for the following resources:

— Air Quality
— Coastal Barrier Beaches and Associated Dunes
— Wetlands
— Seagrass
— Live Bottoms (Pinnacle Trend and Low Relief)
— Topographic Features
— Sargassum
— Chemosynthetic and Nonchemosynthetic Deepwater Benthic Communities
— Marine Mammals
— Sea Turtles
— Alabama, Choctawhatchee, St. Andrew, and Perdido Key Beach Mice
— Coastal and Marine Birds
— Gulf Sturgeon
— Fish Resources and Essential Fish Habitat
— Commercial Fishing
— Recreational Fishing
— Human Resources and Land Use
— Soft Bottoms
— Diamondback Terrapins

Impacts to some Gulf of Mexico resources would be different from the impacts of the proposed action. These impacts are described below.

Impacts on Water Quality

Bottom-area disturbance resulting from platform emplacement and removal, drilling activities, and blowouts results in some level of increased water-column turbidity in overlying offshore waters. Generally, each of these operations has been shown to produce localized, temporary impacts on water quality conditions in the immediate vicinity of the emplacement operation (**Chapters 3.1 and 3.2**). Alternative C would eliminate impacts associated with platform emplacement in the areas within 15 mi (24 km) of the coast of Baldwin County, Alabama.

The oil-spill events related to the proposed action under Alternative A were projected to be mostly very small events, to be very infrequent for spills greater than 50 bbl, to have effects for only a short-duration (from a few days to 3 months), and to affect only a small area of offshore waters at any one time (Chapter 4.3.1 of the Multisale EIS). These events would not be eliminated as a result of Alternative C. The risk of spills due to exploration and development would be eliminated within the deferral area.

Impacts on Archaeological Resources

As a result of the CPA proposed action, Federal waters offshore Alabama were assumed to have new exploration, delineation, and development wells drilled. There would be platform installations and pipelines laid in the area. The location of any proposed activity within a lease block that has a high potential for historic shipwrecks requires archaeological clearance prior to operations. The probability of

an OCS activity contacting and damaging a shipwreck is low; the required clearance measures are considered to be 90 percent effective at protecting potential unknown historic shipwrecks. If an OCS structure did contact a historic resource, unique archaeological information contained within a site or resource could be lost. Under Alternative C, drilling activities and installation of platforms within 15 mi (24 km) of the shoreline of Baldwin County, Alabama, would not occur. Any potential impacts from drilling activities or platform emplacement to historic shipwrecks would be eliminated in OCS blocks within 15 mi (24 km) of the Baldwin County shoreline.

Impacts on Recreational Resources

The major impact-producing factors that could potentially affect recreational beaches include the presence of offshore structures, pipelaying activities, support helicopter and vessel traffic, trash and debris, and oil spills. Exploratory rig activity and platforms associated with OCS development activity could be viewed from coastal communities along the Gulf of Mexico when they are closer than approximately 10 mi (16 km) from shore; beyond that, structures appear very small and barely discernable to the naked eye, eventually disappearing from view. Alternative C would exclude those blocks within 15 mi (24 km) of the shoreline from leasing. No OCS structures would be constructed within the excluded area. Any visual impact due to OCS structures in the area off Baldwin County, Alabama, would be eliminated. Pipelaying activities, support helicopter and vessel traffic, trash and debris, and oil spills from the remaining areas offered from lease would continue to present potential impacts to recreational beaches.

Cumulative Impacts

With the exception of the water quality, archaeological resources, and recreational resources, the cumulative impacts of Alternative C on the environmental and socioeconomic resources of the Gulf of Mexico would be identical to Alternative A. The incremental contribution to cumulative impacts on water quality, archaeological resources, and recreational resources within 15 mi (24 km) of the Baldwin County coast would be reduced or eliminated.

Summary and Conclusion

Alternative C, if adopted, prevent any oil and gas activity whatsoever in the blocks within 15 miles of Baldwin County, Alabama coast thus, it would eliminate any potential direct impacts to the biota of those blocks from oil and gas activities, which otherwise would be conducted within the blocks. Bottom disturbances from platform emplacements and removals, drilling activities, and blowouts would not occur within the excluded area under Alternative C. Therefore, localized, temporary impacts to water quality due to sediment resuspension would be eliminated in the area within 15 mi (24 km) of the Baldwin County coast. Additionally, the risk of oil-spill impacts would be slightly reduced as exploration and development operations would not occur in the excluded area.

The probability of an OCS activity contacting and damaging a shipwreck is low because of existing mitigation in the form of archaeological clearance requirements for proposed activities. Alternative C would eliminate the potential for impacts from drilling or platform emplacement to historic archaeological resources within the area excluded under Alternative C.

Since no OCS structures would be constructed under Alternative C in the excluded blocks, any visual impact due to OCS structures in the area off Baldwin County would be eliminated.

4.1.4. Alternative D—No Action

Description of the Alternative

Alternative D is equivalent to cancellation of a lease sale scheduled for a specific period in the *Final Proposed Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012.* By canceling the proposed lease sale, the opportunity is postponed for development of the estimated 0.801-1.624 BBO and 3.332-6.560 Tcf of gas, some of which may be foregone. Any potential environmental and

socioeconomic impacts resulting from the proposed lease sale (**Chapter 4.1.1**, Alternative A—The Proposed Action) would be postponed or not occur.

Effects of the Alternative

Under Alternative D, DOI cancels the proposed CPA lease sale. Therefore, the discovery and development of oil and gas expected from a lease sale would be delayed and a portion may not occur. The environmental and socioeconomic effects of Alternative A (the proposed action) also would be delayed or not occur.

This Agency recently published a report that examined previous exploration and development activity scenarios (USDOI, MMS, 2007e). The Agency compared forecasted activity with the actual activity from 14 WPA and 14 CPA lease sales.

The report shows that many lease sales contribute to the present level of OCS activity, and any single lease sale accounts for only a small percentage of the total OCS activities. In 2006, leases from 92 different sales contributed to Gulf of Mexico production, while an average CPA lease sale contributed to 2 percent of oil production and 2 percent of gas production in the CPA. In 2006, leases from 15 different sales contributed to the installation of production structures in the Gulf of Mexico, while an average CPA lease sale contributed to 6 percent of the installation of production structures in the CPA. In 2006, leases from 70 different sales contributed to wells drilled in the Gulf of Mexico, while an average CPA lease sale contributed to 4 percent of wells drilled in the CPA.

Like past lease sales, the proposed CPA lease sale would contribute to maintaining the present level of OCS activity in the Gulf of Mexico. Exploration and development activity, including service-vessel trips, helicopter trips, and construction, that would result from the proposed lease sale would replace activity resulting from existing leases that have reached, or are near the end of, their economic life.

Environmental Impacts

If the proposed lease sale would be canceled, the resulting development of oil and gas would most likely be postponed to a future sale; therefore, the overall level of OCS activity in the CPA would only be reduced by a small percentage, if any. Therefore, the cancellation of one lease sale would not significantly change the environmental impacts of overall OCS activity.

Economic Impacts

A sudden change in policy that restricts access to oil and gas resources or that alters the timetables the offshore industry has come to depend on when making their investment decisions may lead to undesirable socioeconomic disruptions in local coastal economies (USDOI, MMS, 2007e). Since 1983, this Agency has scheduled and held annual areawide lease sales in the Gulf of Mexico, canceling only one lease sale. In October 2006, this Agency and the State of Louisiana reached a settlement on the lawsuit filed by the State challenging WPA Lease Sale 200. As part of this settlement, this Agency canceled CPA Lease Sale 201, scheduled for March 2007. However, the acreage was offered 7 months later in CPA Lease Sale 205 (October 2007). This Agency canceled WPA Lease Sale 215 in July 2010 after the *Deepwater Horizon* event. Direct economic impacts are occurring from the cancellation of WPA Lease Sale 215; however, there are limitations to BOEMRE's awareness for what business decisions industry has made or intends to make that are the result of the cancellation of WPA Lease Sale 215, let alone the consequences of selecting Alternative D to cancel a CPA lease sale.

The cancellation of a lease sale may have economic impacts on an industry that has planned their investments according to annual lease sales in the Gulf of Mexico. Smaller independent companies would have fewer alternative projects available in their investment portfolios, and thus would be more affected by the cancellation of the lease sale. Therefore, they would have a more difficult time than major companies replacing lost production capacity. The magnitude and length of economic impacts on industry would be dependent on individual firm characteristics, global trends, and the number of lease sales canceled or delayed.

Canceling the lease sale would result in delaying the subsequent development activities that would take place. Revenues collected by the Federal Government (and thus revenue disbursements to the States) would be adversely affected by such a delay due to the "time value of money" (i.e., a dollar received in

the future is valued less than the same dollar received today because of the opportunity to earn interest). Canceling the lease sale would delay the receipt of interest on billions of dollars of bonus bids, rental income, and royalty income by the Federal treasury.

Other Sources of Energy

Other sources of energy may substitute for the delayed or lost production. Principal substitutes would be additional imports, conservation, additional domestic production, and switching to other fuels. These alternatives, except conservation, have their own significant negative environmental and socioeconomic impacts.

Chapter 4.2.1.4 of the Multisale EIS briefly discusses the most likely alternative energy sources, the quantities expected to be needed, and the environmental and socioeconomic impacts associated with these alternative energy sources. The discussion is based on material from the following publications: *Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012* (USDOI, MMS, 2007a); *Gulf of Mexico Outer Continental Shelf Oil and Gas Leasing Program: 2007-2012, Final Environmental Impact Statement* (USDOI, MMS, 2007c); and *Energy Alternatives and the Environment* (King, 2007).

Summary and Conclusion

If Alternative D is selected, all impacts, positive and negative, associated with the CPA proposed action discussed in **Chapter 4** would be eliminated. The incremental contribution of the proposed action to cumulative effects would also be eliminated, but effects from other activities, including other OCS lease sales, would remain.

If the lease sale would be canceled, the resulting oil and gas exploration and development activity would most likely be postponed to a future sale; therefore, the overall level of OCS activity in the CPA would only be reduced by a small percentage, if any. Therefore, the cancellation of the proposed lease sale would not significantly change the environmental impacts of overall OCS activity. The WPA Lease Sale 215 was canceled on July 28, 2010 (*Federal Register*, 2010g). The impact on oil and gas activity in the GOM of selecting Alternative D to cancel another lease sale is more problematic in forecasting the combined impact on industry levels of activity resulting from two canceled GOM lease sales. Direct economic impacts have undoubtedly already occurred from the cancellation of WPA Lease Sale 215; however, there are limitations to BOEMRE's awareness for what business decisions industry has made or intends to make that are the result of the cancellation of WPA Lease Sale 215, let alone selecting Alternative D to cancel a CPA lease sale.

As an oil province, so far the highest daily oil production rate in the GOM has been 1.73 million barrels/day (MMbbl/d) in June 2002 (The Oil Drum, 2009). On January 3, 2011, Casselman and Gilbert (2011a) reported that a slowed permitting process in the GOM has long-term implications for U.S. oil production. The DOE's Energy Information Administration reported that domestic crude oil production in the U.S. in 2010 as 5.51 MMbbl/d. The DOE's Energy Information Administration also reported that production in the GOM would decline 190,000 bbl/d in 2011 and 2012 (USDOE, Energy Information Administration, 2011b). The forecasted production declines in the GOM are partially offset by projected increases in the lower-48, non-GOM production of 220,000 bbl/d in 2011 and 70,000 bbl/d in 2012. The DOE's Energy Information Administration also reported that a drop in GOM natural gas production in 2011 and 2012 would be more than offset by increases in production in the lower 48 states (USDOE, Energy Information Administration, 2011b). The duration of the decline reported by DOE's Energy Information Administration for GOM oil production is uncertain, as is the question of whether or not GOM oil production will return to pre-DWH event levels of approximately 1.6 MMbbl/d in 2009 (USDOE, Energy Information Administration, 2010e).

Some operators have been reported to be shifting investments out of the Gulf (Casselman and Gilbert, 2011a). BP PLC recently said it would move a brand-new rig that was meant to work in the Gulf, Pride International Inc.'s *Deep Ocean Ascension*, to Libya. Marathon Oil Corp. has tried to cancel a contract for a newly built Gulf rig owned by Noble Corp. (Casselman and Gilbert, 2011a). When the new suspension of deepwater drilling was announced on July 12, 2010, by Secretary of the Interior Ken Salazar, some industry leaders predicted thousands of layoffs and a quick exodus of rigs from the Gulf. Instead, most companies either kept their rigs on stand-by or kept them busy with jobs that were not

covered by the suspension, such as decommissioning nonproducing equipment and plugging and abandoning nonproductive wells (Casselman and Gilbert, 2011a).

There are signs that companies remain committed to the Gulf. On December 16, 2010, Chevron announced 2011 commitments to further develop discoveries at Big Foot, Jack/St. Malo, Tahiti-2, Perdido, and Buckskin. Gilbert (2011) reported that deepwater operators, such as Transocean Ltd., had 12 of 13 deepwater rigs leased for work in the GOM.

On January 3, 2011, Casselman and Gilbert (2011b) reported that the Obama Administration announced an agreement to clear a path for 13 companies drilling deepwater prospects at the time of the moratorium to renew drilling 16 of these projects. The plans controlling the drilling operations must be revised to comply with new safety regulations, but new environmental reviews under NEPA in most cases would not be required.

Smaller oil companies that often work in shallower water, however, are less able to wait out a slowdown if paying high fixed costs for rigs that are idle because of longer permitting timeframes. On January 4, 2011, Gilbert (2011) reported that of the 83 shallow-water rigs in the Gulf, 29 were leased as of December 20, compared with 39 at the time of the DWH event. Among the hardest hit have been Hercules Offshore Inc. and Seahawk Drilling Inc., both of Houston, Texas. Gilbert (2011) contains a graphic showing GOM shallow-water operators and the number of rigs owned versus the number of rigs now leased. Some of these operators are going through layoffs, such as Hercules, which let go 2,000 workers over the last 18 months (Gilbert, 2011).

One condition to which operators pay close attention is uncertainty in access to new land offerings on the OCS or access to their current leases in the face of large capital costs under existing contracts that assumed work would proceed expeditiously. The outcomes of numerous Presidential and Secretarial inquiries following the DWH event (**Appendix D and Table 2-1**) are not yet totally known with respect to how recommendations could influence regulations. Since the October 14, 2010, release of the new safety regulations, industry and BOEMRE's experience for the ramp-up time needed to understand and reach compliance with them has proven to be a work in progress. Both conditions, immediate new requirements and possible future unknown requirements, has lead to uncertainty.

Alternative D, the cancellation of CPA Lease Sale 216/222, on top of already canceled WPA Lease Sale 215, would manifest further impacts. The magnitude would depend on the operating plans of individual companies that currently operate or hold leases in the GOM and that also operate in other areas of the world. The last CPA sale, Lease Sale 213, was held on March 17, 2010. The end of the current 5-Year Program (2007-2012) is June 30, 2012. Cancellation of the last CPA lease sale in the 5-Year Program would cause operators to face the prospect of no new leasing in the CPA for 2 years at a minimum.

Operators that have interests worldwide must balance their company resources against multiple, independent variables. Among these variables are future price forecasts, geologic basin (e.g., if it is gas prone or oil prone), quality of prospect inventory in each basin, the in-house maturation state of prospect inventories, partnering relationships with other operators or national oil companies, and in-country operator risk (e.g., if the country has a stable political environment and legal system to protect investment). The U.S. has been long regarded as a favorable operating environment because of a strong tradition for the rule of law, a stable political system, a tested leasing program with regular opportunities to secure access to land in lease sales, and a mature regulatory system for OCS operations.

Alternative D, in combination with canceled WPA Lease Sale 215, could cause a company to reevaluate operator risk in rebalancing a worldwide portfolio of operating opportunities. If a company begins to view lease sale predictability as being in question or at least counter to longstanding experience in the GOM, it may decide to shift its attention and assets to other places in the world until new and predictable processes are developed and tested. Because contracts tend to be multiyear, a commitment of drilling rigs and other support services to operate in other geologic basins could extend from 2 to 5 years.

Alternative D would also negatively affect revenues collected by the Federal Government and the revenue distributions to the States that are based on total revenue.

Other sources of energy may partially substitute for the lost production. Principal substitutes would be additional imports, conservation, additional domestic production, and switching to other fuels. Except for conservation, these alternatives have negative environmental impacts of their own, some of which are significant. For example, increased tanker traffic in U.S. territorial waters carries with it the risk for

collisions and oil spills. The quantity spilled in tanker accidents or collisions could be large and take place instantaneously for the most part.

4.2. Unavoidable Adverse Impacts of the Proposed Action

Unavoidable adverse impacts associated with the proposed action are expected to be primarily short term and localized in nature and are summarized below. All OCS activities involve temporary and exclusive use of relatively small areas of the OCS over the lifetimes of specific projects. Lifetimes for these activities can be days, as in the case of seismic surveys; or decades, as in the case of a production structure or platform. No activities in the OCS Program involve the permanent or temporary use or “taking” of large areas of OCS on a semicontinuous basis. Cumulatively, however, a multitude of individual projects results in a major use of OCS space.

Sensitive Coastal Habitats: If an oil spill contacts beaches or barrier islands, the removal of beach sand during cleanup activities could result in adverse impacts if the sand is not replaced, and a beach could experience several years of tarballs washing ashore over time, causing an aesthetic impact. Sand borrowing on the OCS for coastal restorations involves the taking of a quantity of sand from the OCS and depositing it onshore, essentially moving small products of the deltaic system to another location. If sand is left where it is, it would eventually be lost to the deltaic system by redeposition or burial by younger sediments; if transported onshore, it would be lost to burial and submergence caused by subsidence and sea-level rise.

If an oil spill contacts coastal wetlands, adverse impacts could be high in localized areas. In more heavily oiled areas, wetland vegetation could experience suppressed productivity for several years; in more lightly oiled areas, wetland vegetation could experience die-back for one season. Epibionts on wetland vegetation and grasses in the tidal zone could be killed, and the productivity of tidal marshes for the vertebrates and invertebrates that use them to spawn and develop could be impaired. Much of the wetland vegetation would recover over time, but some wetland areas could be converted to open water. Some unavoidable impacts could occur during pipeline and other related coastal construction, but regulations are in place to avoid and minimize these impacts to the maximum extent practicable. Unavoidable impacts resulting from dredging, wake erosion, and other secondary impacts related to channel use and maintenance would occur as a result of the proposed action.

Sensitive Coastal and Offshore Biological Habitats: Unavoidable adverse impacts would take place if an oil spill occurred and contacted sensitive coastal and offshore biological habitats, such as *Sargassum* at the surface; fish, turtles, and marine mammals in the water column; or benthic habitats (live bottoms) on the bottom. There could be some adverse impacts on organisms contacted by oil, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals that, at this time, are not well understood.

Water Quality: Unavoidable adverse impacts from routine offshore operations are dependent in large part on the quality of the water. Drilling, construction, overboard discharges of drilling mud and cuttings, and pipelaying activities would cause an increase in the turbidity of the affected waters for the duration of the activity periods. This, however, would only affect water in the immediate vicinity of the construction activity or in the vicinity of offshore structures, rigs, and platforms. The discharge of treated sewage from manned rigs and platforms would increase the levels of suspended solids, nutrients, chlorine, and biochemical oxygen demand in a small area near the discharge point for a short period of time. Accidental spills from platforms and the discharge of produced waters could result in increases of hydrocarbon levels and trace metal concentrations in the water column in the vicinity of the platforms. Spilled oil from a tanker collision would affect the water surface in combination with dispersant chemicals used during spill response. A subsurface blowout would subject the surface, water column, and near-bottom environment to spilled oil and exsolved gas, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals.

Unavoidable impacts to onshore water quality would occur as a result of chronic point- and nonpoint-source discharges such as runoff and effluent discharges from existing onshore infrastructure used in support of lease sale activities. Vessel traffic contributes to the degradation of water quality by chronic low-quantity oil leakage, treated sanitary and domestic waste, bilge water, and contaminants known to exist in ship paints. Regulatory requirements of the State and Federal water authorities and some local

jurisdictions would be applicable to point-source discharges from support facilities such as refineries and marine terminals.

Air Quality: Unavoidable short-term impacts on air quality could occur after large oil spills and blowouts because of evaporation and volatilization of the lighter components of crude oil, combustion from surface burning, and aerial spraying of dispersant chemicals. Mitigation of long-term effects from offshore engine combustion during routine operations would be accomplished through existing regulations and development of new control emission technology. Short-term effects from nonroutine spill events are uncontrollable and are likely to be aggravated or mitigated by the time of year the spills take place.

Endangered and Threatened Species: Unavoidable adverse impacts on endangered and threatened marine mammals, birds, sea turtles, Gulf sturgeon, and hermatypic corals because of routine activities associated with the proposed action (e.g., seismic surveys, water quality and habitat degradation, helicopter disturbance, vessels and collisions with vessels, and discarded trash and debris) would be primarily negligible to minor to a population, but they could be lethal to individuals. Large oil-spill events or the response activities to them could adversely impact endangered species that are directly oiled or that come into contact with emulsions of oil droplets and dispersant chemicals. Large oil spills are expected to be rare, but depending on time and place, the acute impacts from oiled animals could kill tens to hundreds of individuals.

Nonendangered and Nonthreatened Marine Mammals: Unavoidable adverse impacts to nonendangered and nonthreatened marine mammals would be those that also affect endangered and threatened marine mammal species. Routine operation impacts (such as seismic surveys, water quality and habitat degradation, helicopter disturbance, vessel collision, and discarded trash and debris) would be negligible or minor to a population, but they could be lethal to individuals as in the case of a vessel collision. A large oil spill would temporarily degrade habitat if spilled oil, dispersant chemicals, or emulsions of dispersed oil droplets and dispersant chemicals contact free-ranging pods or spawning grounds.

Beach Mice: Impacts to the Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice are possible but unlikely. Impacts may result from consumption of beach trash and debris. The proposed action would deposit only a small portion of the total debris that would reach the habitat. Oil-spill-response and cleanup activities could also have a significant impact to the beach mice and their habitat if not properly regulated. However, potential spills that could result from the proposed action are not expected to contact beach mice or their habitats.

Coastal and Marine Birds: Unavoidable adverse impacts from routine operations on coastal birds could result from helicopter and OCS service-vessel traffic, facility lighting, and floating trash and debris. Marine birds could be affected by noise, platform lighting, aircraft disturbances, and trash and debris associated with offshore activities. Cross-Gulf migrating species could be affected by lighted platforms, helicopter and vessel traffic, and floating trash and debris. If a large oil spill occurs and contacts coastal or marine bird habitats, some birds could experience lethal and sublethal impacts from oiling, and birds feeding or resting in the water could be oiled and die. Coastal birds coming into contact with oil may migrate more deeply into marsh habitats, out of reach from spill responders seeking to count them or collect them for rehabilitation. Oil spills and oil-spill cleanup activities could also affect the food species for coastal, marine, and migratory bird species.

Fish Resources and Commercial Fisheries: Unavoidable adverse impacts from routine operations are loss of open ocean or bottom areas desired for fishing by the presence or construction of OCS facilities and pipelines. Loss of gear could occur from bottom obstructions around platforms and subsea production systems. Routine discharges from vessels and platforms are minor given the available area for fish habitat. If a large oil spill occurs, the oil, dispersant chemicals, or emulsions of oil droplets and dispersant chemicals could temporarily displace mobile fish species on a population or local scale. It is unlikely that fishermen would want, or be permitted, to harvest fish in the area of an oil spill, as spilled oil could coat or contaminate commercial fish species rendering them unmarketable.

Recreational Beaches: Unavoidable adverse impacts from routine operations may result in the accidental loss overboard of some floatable debris that may eventually come ashore on frequented recreational beaches. A large oil spill could make landfall on recreational beaches, leading to local or regional economic losses and stigma effects, causing potential users to avoid the area after acute impacts

have been removed. Some recreational beaches become temporarily soiled by weathered crude oil, and tarballs may come ashore long after stranded oil has been cleaned from shoreline areas.

Economic Activity: Net economic, political, and social benefits accrue from the production of hydrocarbon resources. Once these benefits become routine, unavoidable adverse impacts from routine operations follow trends in supply and demand based on the commodity prices for oil, gas, and refined hydrocarbon products. Declines in oil and gas prices can lead to activity ramp downs by operators until prices rise. A large oil spill would cause temporary increases in economic activity associated with spill-response activity. An increase in economic activity from the response to a large spill could be offset by temporary work stoppages that are associated with spill-cause investigations and would involve a transfer or displacement of demand to different skill sets. Routine operations affected by new regulations that are incremental would not have much affect on the baseline of economic activity; however, temporary work stoppages or the introduction of several new requirements at one time that are costly to implement could cause a drop off of activity as operators adjust to new expectations or use the opportunity to move resources to other basins where they have interests.

Archaeological Resources: Unavoidable adverse impacts from routine operations could lead to the loss of unique or significant archaeological information if unrecognized at the time an area is disturbed. Required archaeological surveys significantly reduce the potential for this loss by identifying potential archaeological sites prior to an interaction occurring, thereby making avoidance or mitigation of impacts possible. A large oil spill could make landfall on or near protected archaeological landmarks to cause temporary aesthetic or cosmetic impacts until the oil is cleaned or degrades.

4.3. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible or irretrievable commitment of resources refers to impacts or losses to resources that cannot be reversed or recovered. Examples are when a species becomes extinct or when wetlands are permanently converted to open water. In either case, the loss is permanent.

Wetlands: An irreversible or loss of wetlands and associated biological resources could occur if wetlands are permanently lost because of impacts caused by dredging and construction activities that displace existing wetlands or from oil spills severe enough to cause permanent die-back of vegetation and conversion to open water. Construction and emplacement of onshore pipelines in coastal wetlands displace coastal wetlands in disturbed areas that are then subject to indirect impacts like saltwater intrusion or erosion of the marsh soils along navigation channels and canals. Ongoing natural and anthropogenic processes in the coastal zone, only one of which is OCS-related activity, can result in direct and indirect loss of wetlands. Natural losses as a consequence of the coastal area becoming hydrologically isolated from the Mississippi River that built it, sea-level rise, and subsidence of the delta platform in absence of new sediment added to the delta plain appear to be much more dominant processes impacting coastal wetlands.

Sensitive Nearshore and Offshore Biological Resources: An irreversible loss or degradation of ecological habitat caused by cumulative activity tends to be incremental over the short term. Irretrievable loss may not occur unless or until a critical threshold is reached. It can be difficult or impossible to identify when that threshold is, or would be, reached. Oil spills and chronic low-level pollution can injure and kill organisms at virtually all trophic levels. Mortality of individual organisms can be expected to occur, and possibly a reduction or even elimination of a few small or isolated populations. The proposed biological stipulations, however, are expected to eliminate most of these risks.

Threatened and Endangered Species: Irreversible loss of individuals that are protected species may occur after a large oil spill from the acute impact of being oiled or the chronic impact of oil having eliminated, reduced, or rendered suboptimal the food species upon which they were dependent.

Fish Resources and Commercial Fisheries: Irreversible loss of fish and coral resources, including commercial and recreational species, are caused by structural removal using explosives. Fish in proximity to an underwater explosion can be killed. Without the structure to serve as habitat area, sessile, attached invertebrates and the fish that live among them are absent. Removing structures eliminates these special and local habitats and the organisms living there, including such valuable species as red snapper. Continued structure removal, regardless of the technique used, would reduce the net benefits to commercial fishing due to the presence of these structures.

Recreational Beaches: Impacts on recreational beaches from a large oil spill may at the time seem irreversible, but the impacts are temporary. Beaches fouled by a large oil spill would be temporarily unavailable to the people who would otherwise frequent them, but only during the period between landfall and cleanup of the oil, followed by an indefinite lag period during which stigma effects recede from public consciousness.

Archaeological Resources: Irreversible loss of a prehistoric or historic archaeological resource can occur if bottom-disturbing activity takes place without the required survey to demonstrate its absence before work proceeds. A resource can be completely destroyed, severely damaged, or the scientific context badly impaired by well drilling, subsea completions, and platform and pipeline installation, or sand borrowing.

Oil and Gas Development: Leasing and subsequent development and extraction of hydrocarbons as a result of the proposed action represents an irreversible and irretrievable commitment by the removal and consumption of nonrenewable oil and gas resources. The estimated amount of resources to be recovered as a result of the proposed action is presented in **Table 3-1**.

Loss of Human and Animal Life: The OCS oil and gas exploration, development, production, and transportation are carried out under comprehensive, state-of-the-art, enforced regulatory procedures designed to ensure public and work place safety and environmental protection. Nevertheless, some loss of human and animal life is inevitable from unpredictable and unexpected acts of man and nature (i.e., unavoidable accidents, accidents caused by human negligence or misinterpretation, human error, willful noncompliance, and adverse weather conditions). Some normal and required operations, such as structure removal, can kill sea life in proximity to explosive charges or by removal of the structure that served as the framework for invertebrates living on it and the fish that lived with it.

4.4. Relationship between the Short-term Use of Man's Environment and the Maintenance and Enhancement of Long-term Productivity

The short-term effects on various components of the environment in the vicinity of the proposed action are related to long-term effects and the maintenance and enhancement of long-term productivity.

Short-Term Use

Short-term refers to the total duration of oil and gas exploration and production activities. Extraction and consumption of offshore oil and natural gas is a short-term benefit. Discovering and producing domestic oil and gas now delays the increase in the Nation's dependency on foreign imports. Depleting a nonrenewable resource now removes these domestic resources from being available for future use. The production of offshore oil and natural gas from the proposed action would provide short-term energy, and as it delays the increase in the Nation's dependency on foreign imports, it can also allow additional time for ramp-up and development of long-term renewable energy sources or substitutes for nonrenewable oil and gas. Economic, political, and social benefits would accrue from the availability of these natural resources.

The principle short-term use of the leased areas in the GOM would be for the production of 0.801-1.624 BBO and 3.332-6.560 Tcf of gas from the CPA proposed action. The cumulative impacts scenario in the Multisale EIS extended from 2007 to 2046, and the cumulative scenario for this Supplemental EIS extends approximately from 2012 to 2052. The 40-year time period is used because it is the approximate longest life span of activities conducted on an individual lease. The next 40 years is the period of time during which the activities and impacting-factors that follow as a consequence of the proposed lease sale would be influencing the environment.

The specific impacts of the proposed action vary in kind, intensity, and duration according to the activities occurring at any given time (**Chapter 3**). Initial activities, such as seismic surveying and exploration drilling, result in short-term, localized impacts. Development drilling and well workovers occur sporadically throughout the life of the proposed action but also result in short-term, localized impacts. Activities during the production life of a platform may result in chronic impacts over a longer period of time (over 25 years), potentially punctuated by more severe impacts as a result of accidental events or a spill. Platform removal is also a short-term activity with localized impacts, including removal of the habitat for encrusting invertebrates and fish living among them. Many of the effects on physical,

biological, and socioeconomic resources discussed in **Chapter 4** are considered to be short term (being greatest during the construction, exploration, and early production phases). These impacts could be further reduced by the mitigation measures discussed in **Chapter 2**.

The OCS development off Louisiana and Texas has enhanced recreational and commercial fishing activities, which in turn has stimulated the manufacture and sale of larger private fishing vessels and specialized recreational fishing equipment. Commercial enterprises such as charter boats have become heavily dependent on offshore structures for satisfying recreational customers. The proposed action could increase these incidental benefits of offshore development. Offshore fishing and diving has gradually increased in the past three decades, with offshore structures and platforms becoming the focus of much of that activity. As mineral resources become depleted, platform removals would occur and may result in a decline in these activities.

The short-term exploitation of hydrocarbons for the OCS Program in the GOM may have long-term impacts on biologically sensitive coastal and offshore resources and areas if a large oil spill occurs. A spill and spill-response activity could temporarily interfere with commercial and recreational fishing, beach use, and tourism in the area where the spill makes landfall and in a wider area based on stigma effects. The proposed leasing may also result in onshore development and population increases that could cause very short-term adverse impacts to local community infrastructure, particularly in areas of low population and minimal existing industrial infrastructure (**Chapter 4.1.1.18**).

Relationship to Long-Term Productivity

Long-term refers to an indefinite period beyond the termination of oil and gas production. Over a period of time after peak oil production has occurred in the GOM, a gradual easing of the specific impacts caused by oil and gas exploration and production would occur as the productive reservoirs in the GOM have been discovered and produced, and have become depleted. The Oil Drum (2009) showed a graphic demonstrating that peak oil production in the GOM occurred in June 2002 at 1.73 Mbbl/d. Whether or not this date is correct can only be known in hindsight and only after a period of years while production continues. At this time, however, the trend is fairly convincing (The Oil Drum, 2009). There is disagreement on what future production trends may be in the GOM after several operators, BP among them, announced discoveries over the last 5 years (Oil and Gas Journal, 2009) in the Lower Tertiary in ultra-deepwater with large projected reserves. These claims are as yet unproven and there are questions as to the difficulties that may be encountered producing these prospects because of their geologic age, burial depth and high-temperature, high pressure in-situ conditions, lateral continuity of reservoirs, and the challenges of producing from ultra-deepwater water depths.

The GOM's large marine ecosystem is considered a Class II, moderately productive ecosystem (mean phytoplankton primary production 150-300 gChlorophyll-*a*/m^2-yr [The Encyclopedia of Earth, 2008]), based on Sea-viewing Wide Field-of-view Sensor (SeaWiFS) global primary productivity estimates (USDOC, NASA, 2003). After the completion of oil and gas production, a gradual ramp-down to economic conditions without oil and gas activity would be experienced, while the marine environment is generally expected to remain at or return to its normal long-term productivity levels that in recent years has been described as stressed (The Encyclopedia of Earth, 2008). The GOM's large marine ecosystem shows signs of ecosystem stress in bays, estuaries, and coastal regions (Birkett and Rapport, 1999). There is shoreline alteration, pollutant discharge, oil and gas development, and nutrient loading. The overall condition for the U.S. section of this large marine ecosystem, according to USEPA's seven primary indicators (Jackson et al., 2000), is good dissolved oxygen, fair water quality, poor coastal wetlands, poor eutrophic condition, and poor sediment, benthos, and fish tissue (The Encyclopedia of Earth, 2008).

To help sustain the long-term productivity of the GOM ecosystem, the OCS Program provides structures to use as site-specific artificial reefs and fish-attracting devices for the benefit of commercial and recreational fishermen and to sport divers and spear fishers. Approximately 10 percent of the oil and gas structures removed from the OCS are eventually used for State artificial reef programs.

CHAPTER 5

CONSULTATION AND COORDINATION

5. CONSULTATION AND COORDINATION

5.1. DEVELOPMENT OF THE PROPOSED ACTION

The purpose of this Supplemental EIS is to address the remaining proposed Gulf of Mexico CPA OCS oil and gas lease sale (CPA Lease Sale 216/222) scheduled under the *Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017* (5-Year Program). This Supplemental EIS is being prepared because of the potential changes to baseline conditions of the environmental, socioeconomic, and cultural resources that may have occurred as a result of (1) the DWH event between April 20 and July 15, 2010 (the period when oil flowed from the Macondo well in Mississippi Canyon Block 252 [**Figure 1-2**]); (2) the acute impacts that have been reported or surveyed since that time; and (3) any new information that may be available. The environmental resources include sensitive coastal environments, offshore benthic resources, marine mammals, sea turtles, coastal and marine birds, endangered and threatened species, and fisheries. This Supplemental EIS analyzes the potential impacts of the proposed action on the marine, coastal, and human environments.

5.2. NOTICE OF PREPARATION OF THE SUPPLEMENTAL EIS

On November 10, 2010, a Notice of Intent to Prepare a Supplemental EIS (NOI) was published in the *Federal Register*. A second NOI was published on November 16, 2010, to correct clerical errors. Additional public notices were distributed via local newspapers, the U.S. Postal Service, and the Internet. A 45-day comment period, which closed on January 3, 2011, was announced for the NOI. Federal, State, and local governments, along with other interested parties, were invited to send written comments to the Gulf of Mexico OCS Region on the scope of the Supplemental EIS. The comments in these letters are summarized in **Chapter 5.3.2.**

5.3. DEVELOPMENT OF THE DRAFT SUPPLEMENTAL EIS

Scoping for this Supplemental EIS was conducted in accordance with CEQ regulations implementing NEPA. Scoping provides those with an interest in the OCS Program an opportunity to provide comments on the proposed action. In addition, scoping provides BOEMRE an opportunity to update the Gulf of Mexico OCS Region's environmental and socioeconomic information base. The scoping process commenced on November 16, 2010, with the publication of the corrected NOI in the *Federal Register*. Scoping meetings were held in Louisiana, Texas, and Alabama. No meeting had more than 15 attendees. The dates, times, locations, and public attendance of the scoping meetings for this proposed Supplemental EIS were as follows:

Tuesday, November 16, 2010
1:00 p.m. CST until adjournment
Hilton New Orleans Airport
New Orleans, Louisiana
9 registered attendees
4 speakers

Wednesday, November 17, 2010
1:00 p.m. CST until adjournment
Houston Airport Marriott
Houston, Texas
16 registered attendees
5 speakers

Thursday, November 18, 2010
1:00 p.m. CST until adjournment
The Battle House Renaissance
Mobile Hotel and Spa
Mobile, Alabama
13 registered attendees
4 speakers

5.3.1. Summary of Scoping Comments

Comments (both verbal and written) were received from the NOI and the three scoping meetings from Federal, State, and local government agencies; interest groups; industry; businesses; the Seminole Tribe of Florida; and the general public on the scope of the Supplemental EIS, significant issues that should be addressed, alternatives that should be considered, and mitigation measures. All scoping comments received, which were appropriate for a lease sale NEPA document, were considered in the preparation of this Supplemental EIS. All speakers at the scoping meetings were generally supportive of the proposed lease sales and recognized the economic benefits of the OCS Program. Comments received from attendees included the following:

- use currently available new information to evaluate impacts;
- supported holding lease sales as soon as possible;
- move expeditiously to complete the Supplemental EIS;
- cancelling lease sales would harm the economy, damage energy production, depress job creation, and reduce revenues to the State and Federal treasuries;
- resume permitting of existing leases;
- Lease Sales 216, 218, and 222 should be held with no reduction in acreage;
- recommended that the Supplemental EIS incorporate all new regulations and requirements put in place post-Macondo; and
- put no restrictions on drilling in deepwater areas.

5.3.2. Summary of Written Comments Received in Response to the Notice of Intent

In response to the NOI, BOEMRE received 11 individual letters by e-mail, 595 identical form e-letters from an advocacy website, and a package of 3 CD's with over 20,000 identical website-derived form letters from an advocacy group. Information submitted from written comments is summarized in **Table 5-1**, including the form letters submitted by the Consumer Energy Alliance. All scoping comments received that were appropriate for the lease sale NEPA document were considered in the preparation of this Supplemental EIS. Scoping comments appropriate for a lease sale NEPA document include scenario information; physical, biological, and socioeconomic resources to consider; impacting factors and impacts on resources; alternatives to be analyzed; and mitigation measures. Several comments received did not apply to scoping for this document including, but not limited, to scheduling and delays of remaining lease sales, expediting the completion of the Supplemental EIS, impacts from delay of the lease sales that had been scheduled as part of the 5-Year Program, categorical exclusions, and using this Supplemental EIS as a document to tier future lease sales for the 2012-2017 lease sale program. All other comments described in **Table 5-1** were considered in this document.

5.3.3. Cooperating Agency

According to Part 516 of the DOI Departmental Manual, BOEMRE must invite eligible governmental entities to participate as cooperating agencies when developing an EIS, in accordance with the requirements of NEPA and the CEQ regulations. The BOEMRE must also consider any requests by eligible government entities to participate as a cooperating agency with respect to a particular EIS, and then to either accept or deny such requests.

The NOI's published on November 10 and November 16, 2010, included invitations to other Federal agencies and State, tribal, and local governments to consider becoming cooperating agencies in the preparation of this Supplemental EIS. The USEPA (Region 6) and NOAA requested to participate as cooperating agencies. The BOEMRE has accepted NOAA and USEPA (Region 6) as cooperating agencies.

5.4. DISTRIBUTION OF THE DRAFT SUPPLEMENTAL EIS FOR REVIEW AND COMMENT

The BOEMRE sent copies of this Draft Supplemental EIS to the public and private agencies and groups listed below. Local libraries along the Gulf Coast were provided copies of this document; a list of these libraries is available on BOEMRE's Internet website at http://www.gomr.boemre.gov/homepg/regulate/environ/libraries.html.

Federal Agencies

Congress
- Congressional Budget Office
- House Resources Subcommittee on Energy and Mineral Resources
- Senate Committee on Energy and Natural Resources

Department of Commerce
- National Marine Fisheries Service
- National Oceanic and Atmospheric Administration

Department of Defense
- Department of the Air Force
- Department of the Army
  - Corps of Engineers
- Department of the Navy
  - Naval Mine and ASW Command

Department of Energy
- Strategic Petroleum Reserve PMD

Department of the Interior
- Bureau of Ocean Energy Management, Regulation and Enforcement
- Fish and Wildlife Service
- Geological Survey
- National Park Service
- Office of Environmental Policy and Compliance
- Office of the Solicitor

Department of State
- Bureau of Oceans and International Environmental and Scientific Affairs

Department of Transportation
- Coast Guard
- Office of Pipeline Safety

Environmental Protection Agency
- Region 4
- Region 6

Marine Mammal Commission

State and Local Agencies

Alabama
- Governor's Office
- Alabama Highway Department
- Alabama Historical Commission and State Historic Preservation Officer
- Alabama Public Service Commission
- Department of Conservation and Natural Resources
- Department of Environmental Management
- South Alabama Regional Planning Commission
- State Docks Department
- State Legislature Natural Resources Committee
- State Legislature Oil and Gas Committee

Florida
- Governor's Office
- Bureau of Archaeological Research
- City of Gulf Breeze
- City of Panama
- City of Pensacola
- Department of Community Affairs
- Department of Environmental Protection
- Department of State Archives, History and Records Management
- Escambia County
- Florida Coastal Zone Management Office
- Sarasota County Coastal Resources
- State Legislature Natural Resources and Conservation Committee
- State Legislature Natural Resources Committee
- West Florida Regional Planning Council

Louisiana
- Governor's Office
- City of Grand Isle
- City of Morgan City
- City of New Orleans
- Department of Culture, Recreation, and Tourism
- Department of Environmental Quality
- Department of Natural Resources
- Department of Transportation and Development
- Department of Wildlife and Fisheries
- Houma-Terrebonne Chamber of Commerce
- Jefferson Parish Director
- Jefferson Parish President

Lafourche Parish CZM
Lafourche Parish Water District #1
Louisiana Geological Survey
South Lafourche Levee District
St. Bernard Planning Commission
State House of Representatives, Natural Resources Committee
State Legislature, Natural Resources Committee

Mississippi

Governor's Office
City of Gulfport
Department of Archives and History
Department of Natural Resources
Department of Wildlife Conservation
Mississippi Development Authority
State Legislature Oil, Gas, and Other Minerals Committee

Industry

Air Armament Center
Alabama Petroleum Council
American Petroleum Institute
Area Energy LLC
Baker Atlas
Bellwether Group
B-J Services Co
BP Amoco
Chevron U.S.A. Inc.
Coastal Conservation Association
Coastal Environments, Inc.
Continental Shelf Associates, Inc.
Dominion Exploration & Production, Inc.
Ecological Associates, Inc.
Ecology and Environment
Energy Partners, Ltd.
EOG Resources, Inc.
Escambia County Marine Resources
Exxon Mobil Production Company
Florida Petroleum Council
Florida Propane Gas Association
Freeport-McMoRan, Inc.
Fugro Geo Services, Inc.
Gulf Environmental Associates
Gulf of Mexico Newsletter
Horizon Marine, Inc.
Industrial Vehicles International, Inc.
International Association of Geophysical Contractors
J. Connor Consultants
John Chance Land Surveys, Inc.
Marine Safety Office
Midstream Fuel Service
Mote Marine Laboratory
Murphy Exploration & Production
Newfield Exploration Company
NWF Daily News
Petrobras America, Inc.
PPG Industries, Inc.
Propane Market Strategy Newsletter
Science Applications International Corporation
Seneca Resources Corporation
Shell Exploration & Production Company
Stone Energy Corporation
Strategic Management Services-USA
T. Baker Smith, Inc.
Texas Geophysical Company, Inc.
The Houston Exploration Company
Triton Engineering Services Co.
W & T Offshore, Inc.
Washington Post
WEAR-TV

Special Interest Groups

1000 Friends of Florida
Alabama Oil & Gas Board
American Cetacean Society
Audubon Louisiana Nature Center
Bay County Audubon Society
Citizens Assoc. of Bonita Beach
Clean Gulf Associates
Coastal Conservation Association
Earthjustice
Florida Chamber of Commerce
Florida Institute of Oceanography
Florida Marine Research
Florida Natural Area Inventory
Florida Public Interest Research Group
Florida Sea Grant College
Gulf Coast Environmental Defense
Gulf County
Gulf County Atlantic Fisheries
Gulf Island National Seashore
Hernando County Planning Department
Hunt Oil
Izaak Walton League of America, Inc
JOC Venture
Louisiana State University
Marine Mammal Commission
Mission Enhancement Office
Mississippi State University
Mobile Bay National Estuary Program
Natural Resources Defense Council
Nature Conservancy

Nicholas State University
Perdido Key Association
Population Connection
Portersville Revival Group
Sierra Club
South Mobile Communities Association
Southeastern Fisheries Association
The Conservancy
The Conservation Fund
The Daspit Company
The Nature Conservancy
Walton County Growth Management

Ports/Docks

Alabama
Alabama State Port Authority
Port of Mobile

Florida
Panama City Port Authority

Louisiana
Greater Baton Rouge Port Commission
Greater Lafourche Port Commission
Grand Isle Port Commission
Plaquemines Port, Harbor and Terminal District
Port of Baton Rouge
Port of Iberia District
Port of New Orleans
Twin Parish Port Commission
St. Bernard Port, Harbor and Terminal District

Mississippi
Port of Gulfport
State Port Authority

5.5. PUBLIC HEARINGS

In accordance with 30 CFR 256.26, BOEMRE will schedule public hearings soliciting comments on this Supplemental EIS. The hearings also provide the Secretary of the Interior with information from interested parties to help in the evaluation of potential effects of the proposed lease sale. An announcement of the dates, times, and locations of the public hearings will be included in the Notice of Availability for this Supplemental EIS. A copy of the public hearing notices were included with this Supplemental EIS that were mailed to the parties indicated above, posted on BOEMRE's Internet website (http://www.gomr.boemre.gov), and published in local newspapers.

5.6. COASTAL ZONE MANAGEMENT ACT

A consistency review will be performed and a Consistency Determination (CD) will be prepared for the affected States prior to the proposed lease sale. To prepare the CD's, BOEMRE reviews each State's Coastal Management Plan (CMP) and analyzes the potential impacts as outlined in this Supplemental EIS, new information, and applicable studies as they pertain to the enforceable policies of each CMP. The CZMA requires that Federal actions that are reasonably likely to affect any land or water use or natural resource of the coastal zone be "consistent to the maximum extent practicable" with relevant enforceable policies of the State's federally approved coastal management program (15 CFR 930 Subpart C). If an activity will have direct, indirect, or cumulative effects, the activity is subject to Federal consistency.

Based on the analyses, the BOEMRE Director makes an assessment of consistency, which is then sent to each State with the Proposed Notice of Sale. If a State concurs, BOEMRE can hold the lease sale. If the State objects, it must do the following under the CZMA: (1) indicate how BOEMRE's presale proposal is inconsistent with their CMP and suggest alternative measures to bring BOEMRE's proposal into consistency with their CMP; or (2) describe the need for additional information that would allow a determination of consistency. Unlike the consistency process for specific OCS plans and permits, there is no procedure for administrative appeal to the Secretary of Commerce for a Federal CD for presale activities. Either BOEMRE or the State may request mediation. Mediation is voluntary, and the DOC would serve as the mediator. Whether there is mediation or not, the final CD is made by DOI and it is the final administrative action for the presale consistency process. Each Gulf State's CMP is described in Appendix B of the Multisale EIS (USDOI, MMS, 2007b).

5.7. ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1631 *et seq*.) of 1973, as amended (43 U.S.C. 1331 *et seq*.), establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. In accordance with Section 7 of the ESA, BOEMRE consulted with NMFS and FWS on possible and potential impacts from the proposed sale on endangered/threatened species and designated critical habitat under their jurisdiction. A biological assessment was prepared for each consultation. The action area analyzed in the biological assessments included the lease sale area addressed in this Supplemental EIS.

The formal ESA consultation with NMFS was concluded with receipt of the Biological Opinion on July 3, 2007. The Biological Opinion concludes that the proposed lease sale and associated activities in the Gulf of Mexico under the 5-Year Program are not likely to jeopardize the continued existence of threatened and endangered species under NMFS jurisdiction or destroy or adversely modify designated critical habitat. The informal ESA consultation with FWS was concluded with a letter dated September 14, 2007. The FWS concurred with BOEMRE's determination that this proposed action under the 5-Year Program was not likely to adversely affect the threatened/endangered species or designated critical habitat under FWS jurisdiction.

Under these existing consultations with FWS and NMFS, BOEMRE continues to request annual concurrence from both NMFS and FWS to ensure current activities and any actual take remain consistent with the Terms and Conditions of the Biological Opinion. For 2010, NMFS emailed their concurrence to BOEMRE on December 3, 2009, and FWS emailed their concurrence to BOEMRE on December 8, 2009.

The extent and scope of the spill caused by the DWH event represents new information not assessed in the existing ESA Section 7 consultation in the Gulf of Mexico under the current 5-Year Program. As a result of this new information, BOEMRE reinitiated ESA Section 7 consultation on the Multisale EIS with NMFS and FWS on July 30, 2010. The NMFS responded with a letter to BOEMRE on September 24, 2010; FWS responded with a letter to BOEMRE on September 27, 2010. However, NMFS and FWS have placed this consultation on hold given the environmental baseline needing to be updated by the results of the NRDA process. The NRDA data have yet to be released. The existing consultations will remain in effect until the reinitiated consultations are completed.

In the interim, BOEMRE will continue to comply with all Reasonable and Prudent Measures and the Terms and Conditions under these existing consultations, along with implementing the current BOEMRE-imposed mitigation, monitoring, and reporting requirements. Based on the most recent and best available information at the time, BOEMRE will also continue to closely evaluate and assess risks to listed species and designated critical habitat in upcoming environmental compliance documentation under NEPA and other statutes.

5.8. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act, Federal agencies are required to consult with NMFS on any action that may result in adverse effects to EFH. The NMFS published the final rule implementing the EFH provisions of the Magnuson-Stevens Fisheries Conservation and Management Act (50 CFR 600) on January 17, 2002. Certain OCS activities authorized by BOEMRE may result in adverse effects to EFH, and therefore, require EFH consultation.

In March 2000, BOEMRE's Gulf of Mexico OCS Region consulted with NMFS's Southeast Regional Office in preparing a NMFS regional finding for the Gulf of Mexico OCS Region that allows BOEMRE to incorporate the EFH assessments into NEPA documents. The BOEMRE consulted on a programmatic level by letters of July 1999 and August 1999 to address EFH issues for certain BOEMRE OCS activities (i.e., plans of exploration and production, pipeline rights-of-way, and platform removals).

An EFH consultation for the CPA and WPA lease sales included in the 5-Year Program, using the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2003-2007; Central Planning Area Sales 185, 190, 194, 198, and 201; Western Planning Area Sales 187, 192, 196, and 200, Draft Environmental Impact Statement* (USDOI, MMS, 2002b) as the NEPA document, was initiated in March 2002 by this Agency with NMFS's Southeast Regional Office. The NMFS responded in April 2002, endorsing the implementation of resource protection measures previously developed cooperatively by this Agency and NMFS in 1999 to minimize and avoid EFH impacts related to exploration and development activities in

the CPA and WPA. In addition to routine measures, additional conservation recommendations were made. In May 2002, this Agency responded to NMFS, acknowledging receipt and agreement to follow the additional conservation recommendations. The EFH conservation measures recommended by NMFS serve the purpose of protecting EFH. Continuing agreements, including avoidance distances from the topographic features' No Activity Zones and live-bottom pinnacle features, as well as circumstances that require project-specific consultation, appear in the clarifying provisions of NTL 2004-G05.

Effective January 23, 2006, NMFS approved a revision to the EFH rules, acknowledging amendments made by the Gulf of Mexico Fishery Management Council resulting in the identification of habitat areas of particular concern. One of the most important changes noted in the amendment is the elimination of the EFH description and identification from waters between 100 fathoms and the seaward limit of the EEZ.

Further programmatic consultation was initiated and completed for the 5-Year Program's lease sales included in the Multisale EIS. The NMFS concurred by letter dated December 12, 2006, that the information presented in the 2003-2007 Draft Multisale EIS satisfies the EFH consultation procedures outlined in 50 CFR 600.920 and as specified in NMFS's March 17, 2000, findings. Provided that BOEMRE's proposed mitigations, NMFS's previous EFH conservation recommendations, and the standard lease stipulations and regulations are followed as proposed, NMFS agrees that impacts to EFH and associated fishery resources resulting from activities conducted under the 5-Year Program's lease sales would be minimal. Following the DWH event, on July 30, 2010, BOEMRE requested reinitiation of ESA consultation with both NMFS and FWS. The NMFS responded with a letter to BOEMRE on September 24, 2010. The EFH consultation was also addressed in NMFS's letter. The reinitiated consultations are not complete at this time, although BOEMRE and NMFS have had discussions and are working on a new consultation document for the 2012-2017 Multisale EIS.

5.9. NATIONAL HISTORIC PRESERVATION ACT

In accordance with the National Historic Preservation Act (NHPA) (16 U.S.C. 470), Federal agencies are required to consider the effect of their undertakings on historic properties. The implementing regulations for Section 106 of the NHPA (16 U.S.C. 470f), issued by the Advisory Council on Historic Preservation (16 CFR 800), specify the required review process. The BOEMRE initiated a request for consultation with the affected Gulf States and Tribal Nations on November 12, 2010, via a formal letter. A timeline of 30 days was provided and two responses were received.

The State of Louisiana, in a letter to BOEMRE dated December 16, 2010, indicated that no known historic properties will be affected by this undertaking and that consultation regarding the proposed action is not necessary. The Seminole Tribe of Florida-Tribal Historic Preservation Officer (STOF-THPO) responded to BOEMRE's request for consultation on December 6, 2010. The STOF-THPO indicated that there was no objection to the proposed undertaking at this time. The STOF-THPO requested to review the impending remote-sensing survey reports that are to be conducted over the high-probability zones within the project area. Additionally, the STOF-THPO requested to be notified if cultural resources that are potentially ancestral or historically relevant to the Seminole Tribe of Florida are inadvertently discovered at any point during this process. No further responses were received beyond the 30-day timeline and no further requests for consultation were received.

This Section 106 consultation is concluded at this time. The BOEMRE will continue to impose mitigating measures and monitoring and reporting requirements to ensure that historic properties are not affected by the proposed undertaking. The BOEMRE will reinitiate the consultation process with the affected parties should such circumstances warrant further consultation.

CHAPTER 6

REFERENCES CITED

6. REFERENCES CITED

Abramson, D., I. Redlener, T. Stehling-Ariza, J. Sury, A. Banister, and Y. Park. 2010. Impact on children and families of the *Deepwater Horizon* oil spill. National Center for Disaster Preparedness. Mailman School of Public Health, Columbia University, New York, NY.

Acevedo, R., R. Morelock, and R.A. Olivieri. 1989. Modification of coral reef zonation by terrigenous sediment stress. Palaios 4:92-100.

Ackerman, J.T., J.Y. Takekawa, K.L. Kruse, D.L. Orthmeyer, J.L. Yee, C.R. Ely, D.H. Ward, K.S. Bollinger, and D.M. Mulcahy. 2004. Using radiotelemetry to monitor cardiac response of free-living tule greater white-fronted geese (*Anser albifrons elgasi*) to human disturbance. Wilson Bulletin 116:146-151.

Adams, J.A. 1960. A contribution to the biology and postlarval development of the Sargassum fish, *Histrio histrio* (Linnaeus), with a discussion of the Sargassum complex. Bull. Mar. Sci. of the Gulf and Caribbean 10:55-82.

Adcroft, A., R. Hallberg, J.P. Dunne, B.L. Samuels, J.A. Galt, C.H. Barker, and D. Payton. 2010. Simulations of underwater plumes of dissolved oil in the Gulf of Mexico. Geophys. Res. Lett. 37, L18605, doi:10.1029/2010GL044689.

Aguilar-Perera, A. and A. Tuz-Sulub. 2010. Non-native, invasive red lionfish (*Pterois volitans* [Linnaeus 1758]: Scorpaenidae), is the first recorded in the southern Gulf of Mexico, off the Northern Yucatan Peninsula, Mexico. Aquatic Invasions, Volume 5, Supplement 1:S9-S12.

Aguilera, F., J. Méndez, E. Pásaro, and B. Laffon. 2010. Review on the effects of exposure to spilled oils on human health. Journal of Applied Toxicology 30:291-301, doi:10.1002/jat.1521.

Alabama Coastal Area Board. 1980. Inventory of Alabama's coastal resources and uses. Alabama Coastal Area Board Technical Publication. 169 pp.

Alabama Dept. of Conservation and National Resources. 2010a. Alabama's artificial reef program (maps). Internet website: http://www.outdooralabama.com/fishing/saltwater/where/artificial-reefs/. Accessed April 15, 2011.

Alabama Dept. of Conservation and Natural Resources. 2010b. Fishing Alabama: WFF's guiding principles and strategies (fishing regulations). Internet website: https://www.outdooralabama.com/fishing/. Accessed April 15, 2011.

Alexander, S.K. and J.W. Webb. 1987. Relationship of *Spartina alterniflora* growth to sediment oil content following an oil spill. In: Proceedings, 1987 Oil Spill Conference. . . April 6-9, 1988. Baltimore, MD. Washington, DC: American Petroleum Institute. Pp. 445-450.

Alexander-Bloch, B. 2010. Vietnamese-American fishers fight for oil spill claim approval. *The Times Picayune*. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/12/vietnamese-american_fishermen.html. Accessed February 16, 2011.

Allen, A. 2010. Observations & lessons learned: Offshore operations, *Deepwater Horizon* oil spill. Spiltec. 9 pp. Internet website: http://www.boemre.gov/forums/documents/Panel_II_Presentation_3_anchorage.pdf. Posted Summer 2010. Accessed December 23, 2010.

Alonso-Alvarez, C., C. Perez, and A. Velando. 2007a. Effects of acute exposure to heavy fuel oil from the *Prestige* spill on a seabird. Aquatic Toxicology 84:103-110.

Alonso-Alvarez, C., I. Munilla, M. Lopez-Alonso, and A. Velando. 2007b. Sublethal toxicity of the *Prestige* oil spill on yellow-legged gulls. Environment International 33:773-781.

Alsop, F.J. III. 2001. Birds of North America. Smithsonian Handbook. New York: DK Publishing. 1,008 pp.

Altuf'yev, Yu. V., A.A. Romanov, and N.N. Sheveleva. 1992. Histology of the striated muscle tissue and liver in Caspian Sea sturgeons. J. Ichthyol. 32:100-116.

American Association of Port Authorities. 2007. US port ranking by cargo volume 2005. Internet website: http://aapa.files.cms-plus.com/PDFs/adv_table_3-12-07.pdf. Accessed October 5, 2010.

American Petroleum Institute (API). 1989. Effects of offshore petroleum operations on cold water marine mammals: A literature review. Washington, DC: American Petroleum Institute. 385 pp.

American Petroleum Institute (API). 2004. Development of a safety and environmental management program for offshore operations and facilities. Recommended Practice (RP) 75.

Amos, A.F. 1989. The occurrence of hawksbills (*Eretmochelys imbricata*) along the Texas coast. Proceedings of the 9th Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFSC-232. Pp. 9-11.

Anchor Environmental CA, L.P. 2003. Literature review of effects of resuspended sediments due to dredging operations. Prepared for the Los Angeles Contaminated Sediments Task Force, Los Angeles, CA 140 pp.

Anderson, C.M. 2010. Written communication. Email regarding the anticipated OCS spill rate post-Macondo event. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Herndon, VA. August 3, 2010.

Anderson, C.M. and R.P. LaBelle. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science and Technology Bulletin 6(5/6):302-321.

Anderson, D.W., F. Gress, and D.M. Fry. 1996. Survival and dispersal of oiled brown pelicans after rehabilitation and release. Marine Pollution Bulletin 32:711-718.

Anton, A., J. Cebrian, C.M. Duarte, K.L. Heck, Jr., and J. Goff. 2009. Low impact of Hurricane Katrina on seagrass community structure and functioning in the northern Gulf of Mexico. Bulletin of Marine Science 85(1):45-59.

Armstrong, H.W., K. Fucik, J.W. Anderson, and J.M. Neff. 1977. Effects of oilfield brine effluent on benthic organisms in Trinity Bay, Texas. API Publication No. 4201. Washington, DC: American Petroleum Institute.

Ashworth, K. 2010. Written communication. November 10, 2010, multiagency teleconference summary. E-mail from Kenneth Ashworth to Thomas Bjerstedt, December 7, 2010.

Atauz, A.D., W. Bryant, T. Jones, and B. Phaneuf. 2006. Mica shipwreck project: Deepwater archaeological investigation of a 19th century shipwreck in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-072. 116 pp.

Aten, L.E. 1983. Indians of the upper Texas coast. New York, NY: Academic Press. 370 pp.

Atkins, M., S. Mirza, J. Skinner, A. Mathew, and T. Edward. 2006. Pipeline damage assessment from Hurricane Ivan in the Gulf of Mexico. Minerals Management Service, Herndon, VA. TA&R 553.

Atkins, M., T. Edward, D. Johnson, and M. Dance. 2007. Pipeline damage assessment from Hurricanes Katrina and Rita in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 581.

Atlantic and Gulf States Marine Fisheries Commissions. 2004. Guidelines for marine artificial reef materials. Second edition. Number 121. 205 pp. Internet website: http://www.gsmfc.org/pubs/SFRP/Guidelines_for_Marine_Artificial_Reef_Materials_January_2004.pdf.

Aurell, J. and B.K. Gullett. 2010. Aerostat sampling of PCDD/PCDF emissions from the Gulf oil spill in situ burns. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Research Triangle Park, NC. 22 pp. Internet website: http://www.epa.gov/research/dioxin/docs/Gulfinsituburnemissionsampling.pdf.

Austin, D., K. Coelho, A. Gardner, R. Higgins, and T. McGuire. 2002a. Social and economic impacts of outer continental shelf activities on individuals and families. Volume I: Final report. U.S. Dept. of the Interior, Minerals Management Service, New Orleans, LA. OCS Study MMS 2002-022. 298 pp.

Austin, D.E., A. Gardner, R. Higgins, J. Schrag-James, S. Sparks, and L. Stauber. 2002b. Social and economic impacts of outer continental shelf activities on individuals and families. Volume II: Case studies of Morgan City and New Iberia, Louisiana. U.S. Dept. of the Interior, Minerals Management Service, New Orleans, LA. OCS Study MMS 2002-023. 197 pp.

Australian Maritime Safety Authority. 2003. Post spill monitoring: Background paper. Prepared by Wardrop Consulting and the Cawthron Institute for the Australian Maritime Safety Authority and the Marine Safety Authority of New Zealand. Canberra: Australian Marine Safety Authority, Canberra. ISBN: 0 642 70991 2.

Australian Maritime Safety Authority. 2010. Oil spill dispersants: Top 20 frequently asked questions (FAQs). Internet website: http://www.amsa.gov.au/Marine_Environment_Protection/National_plan/General_Information/Dispersants_Information/FAQ_Oil_Spills_Dispersants.asp. Accessed June 29, 2010.

Aversa, J. 2010. Oil spill's economic damage may not go beyond Gulf. Internet website: http://dailycaller.com/2010/06/28/oil-spills-economic-damage-may-not-go-beyond-gulf/. Accessed February 16, 2011.

Avery, M.L., P.F. Springer, and N.S. Dailey. 1980. Avian mortality at man-made structures: An annotated bibliography (revised). U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/54.

Avian Power Line Interaction Committee. 1994. Mitigating bird collisions with power lines: The state of the art in 1994. Edison Electric Institute, Washington, DC.

Awbrey, F.T. and A.E. Bowles. 1990. The effects of aircraft noise and sonic booms on raptors: A preliminary model and a synthesis of the literature on disturbance. Prepared for Noise and Sonic Boom Impact Technology (NSBIT), Advanced Development Program Office, Human Systems Division, OL-AC HSD-NSBIT, Wright-Patterson Air Force Base, OH. NSBIT Technical Operating Report No. 12.

Baca, B.J., T.E. Lankford, and E.R. Gundlach. 1987. Recovery of Brittany coastal marshes in the eight years following the *Amoco Cadiz* incident. In: Proceedings of the 1987 International Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 459-464.

Baca, B., G.A. Ward, C.H. Lane, and P.A. Schuler. 2005. Net environmental benefit analysis (NEBA) of dispersed oil on nearshore tropical ecosystems derived from the 20 year "TROPICS" field study. In: Proceedings of the International Oil Spill Conference. May 15-19, 2005. Miami Beach, FL.

Bahr, L.M., Jr., J.W. Day, and J.H. Stone. 1982. Energy cost accounting of Louisiana fishery production. Estuaries 5(3):209-215.

Bailey H. and P. Thompson. 2010. Effect of oceanographic features on fine-scale foraging movements of bottlenose dolphins. Marine Ecology Progress Series 418:223-233.

Baird, P.H. 1990. Concentrations of seabirds at oil-drilling rigs. Condor 92:768-771.

Bak, R.P. 1978. Lethal and sublethal effects of dredging on coral reefs. Marine Pollution Bulletin 9(1):14-16.

Bak, R.P.M. and J.H.B.W. Elgershuizen. 1976. Patterns of oil-sediment rejection in corals. Marine Biology 37:105-113.

Baker, J.M., R.B. Clark, and P.F. Kingston. 1991. Two years after the spill: Environmental recovery in Prince William Sound and the Gulf of Alaska. Institute of Offshore Engineering, Heriot-Watt University, Edinburgh, EH14 4AS, Scotland. 31 pp.

Baker, J.M., M.L. Guzman, P.D. Bartlett, D.I. Little, and C.M. Wilson. 1993. Long-term fate and effects of untreated thick oil deposits on salt marshes. In: Proceedings of the 1993 International Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 395-399.

Balsam, W.L. and J.P. Beeson. 2003. Sea-floor sediment distribution in the Gulf of Mexico. Deep Sea Research Part I. Oceanographic Research Papers 50(12):1421-1444.

Balseiro, A., A. Espi, I. Marquez, V. Perez, M.C. Ferreras, J.F. Garcia Marin, and J.M. Prieto. 2005. Pathological features in marine birds affected by the *Prestige*'s oil spill in the north of Spain. Journal of Wildlife Diseases 41:371-378.

Bankston, C.L. and M. Zhou. 1996. Go fish: The Louisiana Vietnamese and ethnic entrepreneurship in an extractive industry. National Journal of Sociology 10(1):37-55.

Barkuloo, J.M. 1988. Report on the conservation status of the Gulf of Mexico sturgeon, *Acipenser oxyrhunchus desotoi*. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL.

Barras, J.A. 2006. Land area change in coastal Louisiana after the 2005 hurricanes—a series of three maps: U.S. Dept. of the Interior, Geological Survey. Open-File Report 2006-1274. Internet website: http://pubs.usgs.gov/of/2006/1274/.

Barras, J.A. 2007a. Satellite images and aerial photographs of the effects of Hurricanes Katrina and Rita on coastal Louisiana. U.S. Dept. of the Interior, Geological Survey. Geological Survey Data Series 281. Internet website: http://pubs.usgs.gov/ds/2007/281. Accessed April 15, 2011.

Barras, J.A. 2007b. Land area changes in coastal Louisiana after Hurricanes Katrina and Rita (Chapter 5). In: Farris, G.S., G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins, and D.L. Lavoie, eds. Science and the storms: The USGS response to the hurricanes of 2005. U.S. Dept. of the Interior, Geological Survey. Geological Survey Circular 1306. Pp. 97-112. Internet website: http://pubs.usgs.gov/circ/1306/pdf/c1306_ch5_b.pdf. Accessed April 15, 2011.

Barras, J.A. 2009. Land area change and overview of major hurricane impacts in coastal Louisiana, 2004-08: U.S. Dept. of the Interior, Geological Survey. Scientific Investigations Map 3080, scale 1:250,000, 6 p. pamphlet.

Barras, J.A., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. Historical and projected coastal Louisiana land changes: 1978-2050. USGS Open File Report 03-334.

Barras, J.A., J.C. Bernier, and R.A. Morton. 2008. Land area change in coastal Louisiana: 1956 to 2006 (abstract). In: Lavoie, D. and B. Rosen, eds. USGS Gulf Coast Science Conference and Florida Integrated Science Center Meeting: Proceedings with Abstracts, October 20-23, 2008, Orlando, FL. U.S. Dept. of the Interior, Geological Survey, St. Petersburg, FL. Geological Survey Open-File Report 2008-1329. P. 22.

Barringer, F. 2010. As mess is sent to landfills, officials worry about safety. *The New York Times*, June 14, 2010. Internet website: http://www.nytimes.com/2010/06/15/science/earth/15waste.html. Accessed July 1, 2010.

Barry, J.P., E.E. Adams, R. Bleck, K. Caldeira, K. Carman, D. Erickson, J.P. Kennett, J.L. Sarmiento, and C. Tsouris. 2005. Ecosystem and societal consequences of ocean versus atmosphere carbon storage. American Geophysical Union, fall meeting. Abstract #B31D-01. Internet website: http://adsabs.harvard.edu/abs/2005AGUFM.B31D..01B. Accessed December 2005.

Barry A. Vittor and Associates, Inc. 1985. Tuscaloosa Trend regional data search and synthesis study. Volume I: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Regional OCS Office, Metairie, LA. OCS Study MMS 85-0056. 398 pp.

Barry A. Vittor & Associates, Inc. 2009. Submerged aquatic vegetation mapping in Mobile Bay and adjacent waters of coastal Alabama in 2008 and 2009. Prepared for the Mobile Bay National Estuary Program. v + 16 pp. Internet website: http://www.mobilebaynep.com/wp-content/uploads/2010/07/SAVfinal_Jan2010.pdf.

Barstow, D., L. Dodd, J. Glanz, S. Saul, and I. Urbina. 2010. Regulators failed to address risks in oil Rig fail-safe device. *The New York Times*, June 20, 2010. Internet website: http://www.nytimes.com/2010/06/21/us/21blowout.html?_r=1&pagewanted=1. Accessed January 28, 2011.

Bartha, R. and R.M. Atlas. 1983. Transport and transformations of petroleum: Biological processes. In: Boesch, D.F. and N.N. Rabalais, eds. Long-term environmental effects of offshore oil and gas development. Abingdon, UK: Taylor and Francis. Pp. 287-342.

Bass, A.S. and R.E. Turner. 1997. Relationships between salt marsh loss and dredged canals in three Louisiana estuaries. Journal of Coastal Research 13(3):895-903.

Bassin, N.J. and T. Ichiye. 1977. Flocculation behavior of suspended sediments and oil emulsions. Journal of Sedimentary Research 47(2):671-677.

Bateman, D.H. and M.S. Brim. 1994. Environmental contaminants in Gulf sturgeon of northwest Florida 1985-1991. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 23 pp.

Baumann, R.H. and R.E. Turner. 1990. Direct impacts of outer continental shelf activities on wetland loss in the central Gulf of Mexico. Environ. Geo. Water Sci. 15(3):189-198.

Baumann, P.C., I.R. Smith, and C.D. Metcalfe. 1996. Linkages between chemical contaminants and tumors in benthic Great Lake fishes. J. Great Lakes Res. 22(2):131-152.

Baxter II, L., E.E. Hays, G.R. Hampson, and R.H. Backus. 1982. Mortality of fish subjected to explosive shock as applied to oil well severance on Georges Bank. Woods Hole Oceanographic Institution, Woods Hole, MA. Technical Report WHOI-82-54. 69 pp.

Bea, R.G., N.W. Lai, A.W. Niedoroda, and G.H. Moore. 1983. Gulf of Mexico shallow-water wave heights and forces. In: Proceedings of the Offshore Technical Conference, Houston, TX, May 1983. OTC 4586. Pp. 49-62.

Beale, C.M. 2007. The behavioral ecology of disturbance responses. International Journal of Comparative Psychology 20:111-120.

Beauchamp, G. 2002. Higher-level evolution of intraspecific flock-feeding in birds. Behavioral Ecology and Sociobiology 51:480-487.

Beauchamp, G. 2004. Reduced flocking by birds on islands with relaxed predation. Proceedings of the Royal Society of London B 271:1039-1042.

Beauchamp, G. 2008. What is the magnitude of the group-size effect on vigilance? Behavioral Ecology 19(6):1361-1368.

Beauchamp, G. and G.D. Ruxton. 2008. Disentangling risk dilution and collective detection in the antipredator vigilance of semipalmated sandpipers in flocks. Animal Behavior 75:1837-1842.

Beerkircher, L.R. 2009. Personal communication. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service.

Behrens, E.W. 1988. Geology of a continental slope oil seep, northern Gulf of Mexico. American Association of Petroleum Geologists Bulletin 72(2):105-114.

Beiras, R. and L. Saco-Álvarez. 2006. Toxicity of seawater and sand affected by the *Prestige* fuel-oil spill using bivalve and sea urchin embryogenesis bioassays. Water, Air, and Soil Pollution 177:457-466.

Belanger, L. and J. Bedard. 1990. Energetic cost of man-induced disturbance to staging snow geese. Journal of Wildlife Management 54:36-41.

Bell, W.B. 1972. Animal response to sonic booms. Journal of the Acoustic Society of America 51:758-765.

Bellrose, F.C. 1980. Ducks, geese, and swans of North America: A Wildlife Management Institute book sponsored jointly with the Illinois Natural History Survey. Washington, DC: Stackpole Books. 540 pp.

Bengtsson, L., K.I. Hodges, M. Esch, N. Keenlyside, L. Kornblueh, and J. Luo. 2007. How may tropical cyclones change in a warmer climate? Tellus 59(A):539-561.

Benson, J.B., W.W. Schroeder, and A.W. Shultz. 1997. Sandstone hardbottoms along the western rim of the De Soto Canyon, northeastern Gulf of Mexico. Gulf Coast Assoc. Geo. Soc. Trans. XLVII:43-48.

Berecz, E. and M. Balla-Achs. 1983. Gas hydrates. New York, NY: Elsevier. 343 pp.

Berg, J. 2006. A review of contaminant impacts on Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL.

Berman, A.E. 2005. The debate over subsidence in coastal Louisiana and Texas. Houston Geological Society. Internet website: http://www.hgs.org/en/art/?691. Posted November 24, 2005. Accessed October 5, 2010.

Berns, D.M. 2003. Physiological responses of *Thalassia testudinum* and *Ruppia maritima* to experimental salinity levels. M.Sc. Thesis, University of South Florida, St. Petersburg, FL. 71 pp.

Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley, and A. Unnikrishnan. 2007. Observations; oceanic climate change and sea level. In: Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller, eds. Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Internet website: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch5.html.

Birchwood, R., S. Noeth, and E. Jones. 2008. Safe drilling in gas-hydrate prone sediments: Findings from the 2005 drilling campaign of the GOM gas hydrates Joint Industry Project (JIP). U.S. Dept. of Energy, National Energy Technology Laboratory, Fire in the Ice. Methane Hydrate Newsletter. Winter 2008. Pp. 1-8. Internet website: http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/newsletter/newsletter.htm.

Birkett, S.H. and D.J. Rapport. 1999. A stress-response assessment of the northwestern Gulf of Mexico ecosystem. In: Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, MA: Blackwell Science, Inc. Pp. 438-458.

Bittner, J.E. 1996. Cultural resources and the *Exxon-Valdez* oil spill: An overview. In: Proceedings of the *Exxon-Valdez* Oil Spill Symposium. American Fisheries Society Symposium 18:814-818.

Blanchet, H. 2010. Written communication. Fish kill in Bay Joe Wise. Louisiana Dept. of Wildlife and Fisheries. September 24, 2010.

Block, B.A., H.D. Susanna, B. Blackwell, T.D. Williams, E.D. Prince, C.J. Farwell, A. Boustany, S.L.H. Teo, A. Seitz, A. Walli, and D. Fudge. 2001. Migratory movements, depth preferences, and thermal biology of Atlantic bluefin tuna. Science 293(5533):1310-1314.

Blum, M.D. and H.H. Roberts. 2009. Drowning of the Mississippi Delta due to insufficient sediment supply and global sea-level rise. Nature Geoscience 2:488-491. Internet website: http://www.deltas2010.com/blum2009.pdf.

Boehm, P.D. 1983. Transport processes regarding hydrocarbon and metal pollutants in offshore sedimentary environments. In: Boesch, D.F. and N.N. Rabalais, eds. Long-term environmental effects of offshore oil and gas development. Abingdon, UK: Taylor and Francis.

Boehm, P.D. and D.L. Fiest. 1982. Subsurface distributions of petroleum from an offshore well blowout. The *Ixtoc I* Blowout, Bay of Campeche. Environmental Science and Technology 16(2):67-74.

Boehm, P., D. Turton, A. Raval, D. Caudle, D. French, N. Rabalais, R. Spies, and J. Johnson. 2001. Deepwater program: Literature review, environmental risks of chemical products used in Gulf of Mexico deepwater oil and gas operations. Volume I: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-011. 326 pp.

Boesch D.F. and N.N. Rabalais, eds. 1987. Long-term environmental effects of offshore oil and gas development. Abingdon, Oxford, UK: Taylor and Francis.

Boesch, D.F., M.N. Josselyn, A.J. Mehta, J.T. Morris, W.K. Nuttle, C.A. Simestad, and D.J.P. Swift. 1994. Scientific assessment of coastal wetland loss, restoration and management in Louisiana. Journal of Coastal Research Special Issue 20:1-103.

Boland, G.S. 1986. Discovery of co-occurring bivalve *Acesta* sp. and chemosynthetic tube worms Lamellibrachia. Nature 323:759.

Boland, G. 2010. Personal communication. Mud used in "top kill." U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Herndon, VA.

Boland, G.S. and P.W. Sammarco. 2005. Observations of the antipatharian "black coral" *Plumapathes pennacea* (Pallas, 1766) (Cnidaria: Anthozoa), northwest Gulf of Mexico. Gulf of Mexico Science 23:127-132.

Boland, G., G. Brewer, E. Cordes, A. Demopoulos, C. Fisher, C. German, and K. Sulka. 2010. Mississippi Canyon 252 incident NRDA Tier 1 for deepwater communities: Work plan and SOPs. June 27, 2010. 37 pp. Internet website: http://www.nature.nps.gov/environmentalquality/OilSpillWorkplans/docs/2010_07_02_Deepwater_Communities_Signed.pdf.

Bolden, S. 2010. Personal communication. Information concerning the critical habitat and damage assessments of the Gulf sturgeon. U.S. Dept. of Commerce, NOAA Fisheries, St. Petersburg, FL.

Bologna, P.A.X. and K.L. Heck, Jr. 1999. Macrofaunal associations with seagrass epiphytes: Relative importance of trophic and structural characteristics. Journal of Experimental Marine Biology and Ecology 242(1):21-39.

Bortone, S.A., P.A. Hastings, and S.B. Collard. 1977. The pelagic Sargassum ichthyofauna of the eastern Gulf of Mexico. Northeast Gulf Science 1:60-67.

Boswell, R., T. Collett, D. McConnell, M. Frye, B. Shedd, S. Mrozewski, G. Guerin, A. Cook, P. Godfriaux, R. Dufrene, R. Roy, and E. Jones. 2009. Joint industry project Leg II discovers rich gas hydrate accumulations in sand reservoirs in the Gulf of Mexico. U.S Dept. of Energy, National Energy Technology Laboratory, Fire in the Ice. Methane Hydrate Newsletter. Summer 2009. Pp. 1-5. Internet website: http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/newsletter/newsletter.htm.

Bourgeois, M. 2010a. Written communication. Email regarding fish kills in the MRGO. Louisiana Dept. of Wildlife and Fisheries. August 23, 2010.

Bourgeois, M. 2010b. Written communication. Oyster kill in Bay Jacques. Louisiana Dept. of Wildlife and Fisheries. June 20, 2010.

Boyd, R. and S. Penland, eds. 1988. A geomorphologic model for Mississippi Delta evolution. Transactions—Gulf Coast Association of Geological Societies 38:443-452.

Boyd, R.S., J.M. Moffett, and M.C. Wooten. 2003. Effects of post-hurricane dune restoration and revegetation techniques on the Alabama beach mouse. Final report submitted to U.S. Dept. of the Interior, Fish and Wildlife Service. Auburn University, Alabama. 308 pp.

Brassieur, R., C.E. Colten, and J. Edwards. 2000. Atchafalaya trace heritage area: Historic and cultural resources analysis. Atchafalaya Trace Commission, Baton Rouge, LA.

Bricker, S., B. Longstaff, W. Dennison, A. Jones, K. Boicourt, C. Wicks, and J. Woerner. 2007. Effects of nutrient enrichment in the Nation's estuaries: A decade of change. U.S. Dept. of Commerce,

National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Silver Spring, MD. NOAA Coastal Ocean Program Decision Analysis Series No. 26. 328 pp.

Briggs, K.T., S.H. Yoshida, and M.E. Gershwin. 1996. The influence of petrochemicals and stress on the immune system of seabirds. Regulatory Toxicology and Pharmacology 23:145-155.

Bright, T.J. and R. Rezak. 1978. Northwestern Gulf of Mexico topographic features study: Final report. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Study No. 1978-4. 692 pp. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/4069.pdf.

Bright, T.J., R. Rezak, A.H. Bouma, W.R. Bryant, and W.E. Pequegnat. 1976. A biological and geological reconnaissance of selected topographical features on the Texas continental shelf. Final report to the U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract # 08550-CT5-4.

Britsch, L.D. and J.B. Dunbar. 1993. Land loss rates: Louisiana coastal plain. Journal of Coastal Research 9(2):324-338.

Broder, J.M. 2010. Drillers fault study on moratorium losses. *The New York Times*. Internet website: http://green.blogs.nytimes.com/2010/09/16/drillers-fault-study-on-moratorium-losses/. Accessed December 12, 2010.

Brody, S., S. Bernhardt, H. Grover, C. Spence, Z. Tang, and B. Whitaker. 2006. Identifying potential conflict associated with oil and gas exploration in Texas state coastal waters: A multi-criteria spatial analysis. Environmental Management 38:597-617.

Brooks, J.M., ed. 1991. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume I: Executive summary and Volume II: Technical summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0062 and 91-0063. 43 and 368 pp., respectively.

Brooks, J.M. and C.P. Giammona. 1990. Mississippi-Alabama marine ecosystem study: Annual report; Year 2. Volume I: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0095. 348 pp.

Brooks, J.M. and R.M. Darnell. 1991. Executive summary. In: Brooks, J.M. and C.P. Giammona, eds. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume I: Executive summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. OCS Study MMS-91-0062. 43 pp.

Brooks, R.A. and K.J. Sulak. 2005. Quantitative assessment of benthic food resources for juvenile Gulf sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River estuary, Florida, USA. Estuaries 28:767-775.

Brooks, J.M., M.C. Kennicutt II, and R.R. Bidigare. 1986. Final cruise report for Offshore Operators Committee study of chemosynthetic marine ecosystems in the Gulf of Mexico. Texas A&M University, Dept. of Oceanography, Geophysical and Environmental Research Group, College Station, TX. 102 pp.

Brooks, J.M., C. Fisher, H. Roberts, B. Bernard, I. McDonald, R. Carney, S. Joye, E. Cordes, G. Wolff, and E. Goehring. 2009. Investigations of chemosynthetic communities on the lower continental slope of the Gulf of Mexico: Interim report 2. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-046. 360 pp. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/4/4877.pdf.

Brubaker, L. 2010. Deepwater oil drilling ban by Obama lifted by U.S. judge. BloombergBusinessweek. June 23, 2010. Internet website: http://www.businessweek.com/news/2010-06-23/deepwater-oil-drilling-ban-by-obama-lifted-by-u-s-judge.html. Accessed January 13, 2011.

Bryan, B., N. Harvey, T. Belperio, and B. Bourman. 2001. Distributed process modeling for regional assessment of coastal vulnerability to sea-level rise. Environmental Modeling and Assessment 6:57-65.

Bryant, W., N. Slowey, S. DiMarco, D. Bean, and D. Berti. 2004. DeepSea furrows: Physical characteristics, mechanisms of formation and associated environmental processes. Final report prepared for Research Partnership to Secure Energy for America. 4 pp.

Burdeau, C. and J. Collins. 2010. Gulf's marshes showing new life: Worst fears about spill's effect ease as plants sprout anew. *The Columbus Dispatch*, August 12, 2010. (Interviews with Louisiana Dept. of Wildlife and Fisheries, Matt Boasso; Louisiana Universities Marine Consortium, Alexander S. Kolker; British Petroleum, Ivor Van Heerden; and U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Ben Sherman). Internet website: http://www.dispatch.com/live/content/national_world/stories/2010/08/12/gulfs-marshes-showing-new-life.html?sid=101. Accessed April 2, 2011.

Burger, J. 1977. Determinants of hatching success in diamond-back terrapin, *Malaclemys terrapin*. American Midland Naturalist 97:444-464.

Burger, J. 1981. Behavioural responses of herring gulls *Larus argentatus* to aircraft noise. Environmental Pollution Series A, Ecological and Biological 24:177-184.

Burger, A.E. 1993. Estimating the mortality of seabirds following oil spills: Effects of spill volume. Marine Pollution Bulletin 26:140-143.

Burger, J. 1997. Oil spills. New Brunswick, NJ: Rutgers University Press. 261 pp.

Burns, K.A. and A.H. Knap. 1989. The Bahia las Minas oil spill. Hydrocarbon uptake by reef building corals. Marine Pollution Bulletin 20(8):391-398.

Burns, K.A. and J.M. Teal. 1973. Hydrocarbons in the pelagic sargassum community. Deep Sea Research and Oceanographic Abstracts 20(2):207-211.

Burns, K.A., S.D. Garrity, and S.C. Levings. 1993. How many years until mangrove ecosystems recover from catastrophic oil spills? Marine Pollution Bulletin 26(5):239-248.

Burns III, G.H., C.A. Benson, T. Eason, J. Michel, S. Kelly, and B. Benggio. 1994. Recovery of submerged oil at San Juan, Puerto Rico 1994. International Oil Spill Conference. Internet website: http://www.iosc.org/papers/01798.pdf.

Butler, D. and E. Sayre. 2010. Economic impact of the *Deepwater Horizon* oil spill on south Mississippi: Initial findings on revenue. Internet website: http://www.usm.edu/oilspill/files/white-papers/Oil-Spill-Economic-Impact-Butler-Sayre.pdf.

Butler, R.G., A. Harfenist, F.A. Leighton, and D.B. Peakall. 1988. Impact of sublethal oil and emulsion exposure on the reproductive success of Leach's storm-petrels: Short and long-term effects. Journal of Applied Ecology 25:125-143.

Butler, J.A., R.A. Seigel, and B. Mealey. 2006. *Malaclemys terrapin*—diamondback terrapin. In: Meylan, P.A., ed. Biology and conservation of Florida turtles. Chelonian Research Monographs 3:279-295.

Byrd, G.V., J.H. Reynolds, and P.L. Flint. 2009. Persistence rates and detection probabilities of bird carcasses on beaches of Unalaska Island, Alaska, following the wreck of the M/V *Selendang Ayu*. Marine Ornithology 37:197-204.

Byrne, C. 1989. Effects of the water-soluble fractions of No. 2 fuel oil on the cytokinesis of the Quahog clam (*Mercenaria mercenaria*). Bulletin of Environmental Contamination and Toxicology 42:81-86.

Byrne, C.J. and J.A. Calder. 1977. Effect of the water-soluble fractions of crude, refined, and waste oils on the embryonic and larval stages of the Quahog clam *Mercenaria* sp. Marine Biology 40:225-231.

Byrne, J.H. and J.L. Roberts, eds. 2009. From molecules to networks: An introduction to cellular and molecular neuroscience. 2nd ed. Elsevier: New York, NY.

Byrnes, M.R., R.M. Hammer, B.A. Vittor, J.S. Ramsey, D.B. Snyder, K.F. Bosma, J.D. Wood, T.D. Thibaut, and N.W. Phillips. 1999. Environmental survey of identified sand resource areas offshore Alabama: Volume I: Main text. Volume II: Appendices. U.S. Dept. of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 99-0052. 326 pp. + 132 pp. appendices.

Byron, D. and K.L. Heck, Jr. 2006. Hurricane effects on seagrasses along Alabama's Gulf Coast. Estuaries and Coasts 29(6A):939-942.

Caetano, M., M.J. Madureira, and C. Vale. 2003. Metal remobilization during resuspension of anoxic contaminated sediment: Short-term laboratory study. Water, Air, and Soil Pollution 143:23-40.

Caffey, R.H. 2009. Personal communication. Preliminary estimates of economic damages to Louisiana fisheries and aquaculture sectors as a result of Hurricanes Ike and Gustav in September 2008. Unpublished data, updated September 28, 2008. 2 pp.

Cagle, F.R. 1952. A Louisiana terrapin population (*Malaclemys*). Copeia 1952:74-76.

Camilli, R., C.M. Reddy, D.R. Yoerger, B.A.S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva, and J.V. Maloney. 2010. Tracking hydrocarbon plume transport and biodegradation at Deepwater Horizon. Published online August 19, 2010. Science 8 October 2010: 330:6001(201-204). DOI: 10.1126/science. 1195223.

Campbell, T., L. Benedict, and C.W. Finkl. 2005. Regional strategies for coastal restoration along Louisiana barrier islands. Journal of Coastal Research Special Issue 44. Pp. 245-267.

Camphuysen, K.C.J., M. Heubeck, S.L. Cox, R. Bao, D. Humple, C. Abraham, and A. Sandoval. 2002. The *Prestige* oil spill in Spain. Atlantic Seabirds 4:131-140.

Camphuysen C.J., J. Chardine, M. Frederiksen, and M. Nunes. 2005. Review of the impacts of recent major oil spills on seabirds. In: Anonymous, ed. Report of the Working Group on Seabird Ecology, Texel, 29 March – 1 April 2005. Oceanography Committee, ICES CM 2005/C:05, Ref. ACME+E, International Council for the Exploration of the Sea. Copenhagen, Denmark.

Cardiff, S. 2006. Personal communication. List of seabirds of the northern Gulf of Mexico. Avian Biologist, Louisiana State University Museum of Natural Sciences, Baton Rouge, LA.

Carls, M.G., G.D. Marty, T.R. Meyers, R.E. Thomas, and S.D. Rice. 1998. Expression of viral hemorrhagic septicemia virus in prespawning Pacific herring (*Clupea pallasi*) exposed to weathered crude oil. Canadian Journal of Fisheries and Aquatic Sciences 55(10):2300-2309.

Carlson, P.R., Jr. and K. Madley. 2007. Statewide summary for Florida. In: Handley, D.A., D. Altsman, and R. DeMay, eds. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. Pp. 99-114. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed May 13, 2011.

Carlson, P.R., Jr., L.A. Yarbro, K.A. Kaufman, and R.A. Mattson. 2010. Vulnerability and resilience of seagrasses to hurricane and runoff impacts along Florida's west coast. Hydrobiology 649:39-53.

Carney, R. 1993. Presentation at the Thirteenth Gulf of Mexico Information Transfer Meeting, December 4-6, 1993. Sponsored by the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Carney, R.S. 1997. Workshop on environmental issues surrounding deepwater oil and gas development: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0022. 164 pp.

Carney, R.S. 1999. Status of environmental and physical oceanography information on the continental slope in the Gulf of Mexico—results of a workshop. In: McKay, M. and J. Nides, eds. Proceedings:

Seventeenth annual Gulf of Mexico information transfer meeting, December 1997. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0042. 419 pp. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3206.pdf.

Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68-79.

Carney, R.S., R.L. Haedrich, and G.T. Rowe. 1983. Zonation of fauna in the deep sea. In: Rowe, G.T., ed. Deep-Sea Biology. New York, NY: John Wiley & Sons. Pp. 371-398.

Carpenter, E.J. and J.L. Cox. 1974. Production of pelagic Sargassum and a blue-green epiphyte in the western Sargasso Sea. Limnology and Oceanography 19(3):429-436.

Carr, A. 1983. All the way down upon the Suwannee River. Audubon Magazine. April:80-101.

Carr, A. 1987. New perspectives on the pelagic stages of sea turtle development. Conservation Biology 1(2):103-121.

Carr, A. and A.B. Meylan. 1980. Evidence of passive migration of green turtle hatchlings in Sargassum. Am. Soc. Ichthyologists and Herpetologists 2:366-368.

Carr, R.S., D.C. Chapman, B.J. Presley, J.M. Biedenbach, L. Robertson, P. Boothe, R. Kilada, T. Wade, and P. Montagna. 1996. Sediment porewater toxicity assessment studies in the vicinity of offshore oil and gas production platforms in the Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 53:2618-2682.

Carson, R.T. and W.M. Hanemann. 1992. A preliminary economic analysis of recreational fishing losses related to the *Exxon Valdez* oil spill. A Report to the Attorney General of the State of Alaska. 16 pp.

Cash, R.W., D. Naar, B. Donahue, R. Viso, and P. Gayes. 2010. Pulley Ridge: What newly mapped areas reveal about sea-level change. A presentation at the meeting of the Geological Society of America, March 15, 2010. Internet website: http://gsa.confex.com/gsa/2010NE/finalprogram/abstract_169166.htm.

Casselman, B. 2010. Aging oil rigs, pipelines expose Gulf to accidents. *The Wall Street Journal*. December 14, 2010. Internet website: http://online.wsj.com/article/SB10001424052748704584804575644463302701660.html. Accessed December 2010.

Casselman, B. and D. Gilbert. 2011a. Drilling is stalled even after ban is lifted. *The Wall Street Journal*. Internet website: http://online.wsj.com/article/SB10001424052970204204004576050451696859780.html?mod=WSJ_hp_LEFTTopStories. Posted January 3, 2011. Accessed January 3, 2011.

Casselman, B. and D. Gilbert. 2011b. Path clears for deep-water drilling. *The Wall Street Journal*. Internet website: http://online.wsj.com/article/SB10001424052748704111504576060122314549528.html?mod=WSJ_hp_MIDDLENexttoWhatsNewsTop. Posted January 4, 2011. Accessed January 4, 2011.

Castege, I., Y. Lalanne, V. Gouriou, G. Hemery, M. Girin, F. D'Amico, C. Mouches, J. D'Elbe, L. Soulier, J. Pensu, D. Lafitte, and F. Pautrizel. 2007. Estimating actual seabirds mortality at sea and relationship with oil spills: lesson from the "Prestige" oil spill in Aquitaine (France). Ardeola 54:289-307.

Castellanos, D.L. and L.P. Rozas. 2001. Nekton use of submerged aquatic vegetation, marsh, and shallow unvegetated bottom in the Atchafalaya River Delta, a Louisiana tidal freshwater ecosystem. Estuaries 24(2):184-197.

Chabreck, R.H., T. Joanen, and S.L. Paulus. 1989. Southern coastal marshes and lakes. In: Smith, L.M., R.L. Pederson, and R.M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Chaisson, C. 2010. Personal communication. Port Fourchon activity levels post-moratorium. Executive Director, Greater Lafourche Port Commission, Port Fourchon, LA. December 2, 2010.

Chambers, M. 2010. Gulf Coast ports surrounding the *Deepwater Horizon* oil spill. U.S. Dept of Transportation, Research and Innovative Technology Administration, Fact Sheet. June 2010. 4 pp. Internet website: http://www.bts.gov/publications/bts_fact_sheets/2010_001/pdf/entire.pdf.

Chan, E.I. 1977. Oil pollution and tropical littoral communities: Biological effects of the 1975 Florida Keys oil spill. In: Proceeding of the 1977 Oil Spill Conference, March 8-10, 1977, New Orleans, LA. Washington, DC: American Petroleum Institute.

Chapman, P.M., E.A. Power, R.N. Dexter, and H.B. Andersen. 1991. Evaluation of effects associated with and oil platform, using the sediment quality triad. Environmental Toxicology and Chemistry 10:407-424.

Chapman, F.A., S.F. O'Keefe, and D.E. Campton. 1993. Establishment of parameters critical for the culture and commercialization of Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. University of Florida, Dept. of Fisheries and Aquatic Science, Gainesville, FL. U.S. Dept. of Commerce, National Marine Fisheries Service, St. Petersburg, FL. Project Final Report—NOAA No. NA27FD0066-01.

Chermock, R.L. 1974. The environment of offshore and estuarine Alabama: Alabama Geological Survey Information Series 51. 135 pp.

Chiappone, M. and K.M. Sullivan. 1994. Ecological structure and dynamics of nearshore hard-bottom communities in the Florida Keys. Bulletin of Marine Science 54(3):747-756.

Chin, C.S. and J. Church. 2010. Field report: Fort Livingston, Grand Terre Island (September 9-10, 2010. National Center for Preservation Technology and Training, Natchitoches, LA. Internet website: http://www.ncptt.nps.gov/2011/field-report-fort-livingston-grand-terre-island/. Accessed March 18, 2011.

Cho, H.J. and C.A. May. 2008. Short-term spatial variations in the beds of *Ruppia maritima* (Ruppiaceae) and *Halodule wrightii* (Cymodoceaccae) at Grand Bay National Estuarine Research Reserve, Mississippi, USA. Journal of the Mississippi Academy of Sciences 53(2-3):133-145.

Cho, H.J., P. Biber, and C. Nica. 2009. The rise of *Ruppia maritima* in seagrass beds: changes in coastal environment and research needs. In: Drury, E.K. and T.S. Pridgen, eds. Handbook on Environmental Quality. Hauppauge, NY: Nova Science Publishers, Inc. 418 pp.

Church, R.A. and D.J. Warren. 2008. Viosca Knoll wreck: Discovery and investigation of an early nineteenth-century sailing ship in 2,000 feet of water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-018. 41 pp.

Church, R., D. Warren, R. Cullimore, L. Johnston, W. Schroeder, W. Patterson, T. Shirley. M. Kilgour, N. Morris, and J. Moore. 2007. Archaeological and biological analysis of World War II shipwrecks in the Gulf of Mexico: Artificial reef effect in deep water. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-015. 387 pp.

City of New Orleans. n.d. The New Orleans city assisted evacuation plan. Internet website: http://www.nola.gov/~/media/Files/Emergency%20Prepardness/Emergency%20Preparedness%20Documents/Assisted_Evac_Plan.ashx. Accessed February 17, 2011.

Clapp, R.B., R.C. Banks, D. Morgan-Jacobs, and W.A. Hoffman. 1982. Marine birds of the southeastern United States and Gulf of Mexico. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, DC. FWS/OBS-82/01. 3 vols.

Clark, R.B. 1982. The impact of oil pollution on marine populations, communities, and ecosystems: A summing up. Philosophical Transactions of the Royal Society of London. B 297:433-443.

Clark, R.B. 1984. Impact of oil pollution on seabirds. Environmental Pollution Series A 33:1-22.

Clark, C.E. and J.A. Veil. 2009. Produced water volumes and management practices in the United States. Prepared by the Environmental Science Division, Argonne National Laboratory for the U.S. Dept. of Energy, Office of Fossil Energy, National Energy Technology Laboratory under Contract DE-AC02-06CH11357. ANL/EVS/R-09/1. Internet website: http://www.evs.anl.gov/pub/dsp_detail.cfm?PubID=2437.

Clarke, D.G. and D.H. Wilber. 2000. Assessment of potential impacts of dredging operations due to sediment resuspension. DOER Technical Notes Collection. ERDC TN-DOER-EP. U.S. Dept. of the Army, Research and Development Center, Vicksburg, MS.

Clausen, C.J. and J.B. Arnold III. 1975. Magnetic delineation of individual shipwreck sites; a new control technique. Bull. of the Texas Archaeological Soc. 46:69-86.

Cleveland, C. 2010. *Deepwater Horizon* oil spill. In: Hogan, C.M. and P. Saundry, eds. Encyclopedia of Earth. Washington, DC: Environmental Information Coalition, National Council for Science and the Environment. Internet website: http://www.eoearth.org/article/Deepwater_Horizon_oil_spill?topic=50364. Accessed May 18, 2011.

Clugston, J.P. 1991. Gulf sturgeon in Florida prey on soft-bodied macroinvertebrates. U.S. Dept. of the Interior, Fish and Wildlife Service. Research Information Bulletin No. 90-31. 2 pp.

Clugston, J.P., A.M. Foster, and S.H. Carr. 1995. Gulf sturgeon, *Acipenser onyrinchus desotoi*, in the Suwannee River, Florida, USA. In: Gershanovich, A.D. and T.I.J. Smith, eds. Proceedings of the International Symposium on Sturgeons, September 6- 11, 1993, Moscow, Russia. 370 pp.

Coastal Environments, Inc. (CEI). 1977. Cultural resources evaluation of the northern Gulf of Mexico continental shelf. Prepared for the U.S. Dept. of the Interior, National Park Service, Office of Archaeology and Historic Preservation, Interagency Archaeological Services, Baton Rouge, LA. 4 vols.

Coastal Environments, Inc. (CEI). 1982. Sedimentary studies of prehistoric archaeological sites. Prepared for the U.S. Dept. of the Interior, National Park Service, Division of State Plans and Grants, Baton Rouge, LA.

Coastal Response Research Center. 2007. Submerged oil—State of the practice and research needs. Prepared by the Coastal Response Research Center, Durham, NN. 29 pp. + app. Internet website: http://www.crrc.unh.edu/workshops/submerged_oil/submerged_oil_workshop_report.pdf. Accessed December 27, 2010.

Cohen, Y., A. Nissenbaum, and R. Eisler. 1977. Effects of Iranian crude oil on the Red Sea octocoral *Heteroxenia fuscescens*. Environmental Pollution 12:173-186.

Cohen, J.E., C. Small, A. Mellinger, J. Gallup, and J. Sachs. 1997. Estimates of coastal populations. Science 278:1211–1212.

Cole, K.L. and S.F. DiMarco. 2010. Low-frequency variability of currents in the deepwater eastern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2010-015. 136 pp.

Coleman, F.C., G. Dennis, W. Jaap, C. Koenig, and S. Reed. 2009. The Florida Middle Grounds: Habitat area of particular concern. Florida State University, Coastal and Marine Laboratory, St. Teresa, FL. Internet website: http://www.bio.fsu.edu/coleman_lab/florida_middle_grounds. Accessed April 17, 2011.

Collard, S. 1990. Leatherback turtles feeding near a water mass boundary in the eastern Gulf of Mexico. Marine Turtle Newsletter 50:12-14.

Collard, S.B. and A. Lugo-Fernandez. 1999. Coastal upwelling and mass mortalities of fishes and invertebrates in the northeastern Gulf of Mexico during spring and summer 1998. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS-99-0049. 20 pp.

Collett, T.S. 2002. Energy resource potential of natural gas hydrates. American Association of Petroleum Geologists Bulletin 86(11):1971-1992.

Collins, M.A. 1995. Dredging-induced near-filed resuspended sediment concentrations and source strengths. Final Report D-95-2. U.S. Dept. of the Army, Corps of Engineers. 229 pp.

Collins Center for Public Policy. 2010. Potential impacts of oil and gas explorations in the Gulf. A report to the Century Commission for a Sustainable Florida. 40 pp.

Conan, G. 1982. The long-term effects of the *Amoco Cadiz* oil spill. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 297(1087). The long-term effects of oil pollution on marine populations, communities, and ecosystems. Pp. 323-333.

Connor, M. 2010. US oil spill not sticking to bond issuers-Moody's. Internet website: http://www.xe.com/news/2010-11-22%2015:20:00.0/1539229.htm. Accessed December 8, 2010.

Continental Shelf Associates, Inc. (CSA). 1980. Video and photographic reconnaissance of Phleger and Sweet Banks, northwest Gulf of Mexico. Prepared for the U.S. Dept. of the Interior, Bureau of Land Management. Contract No. AA551-CT9-36.

Continental Shelf Associates, Inc. (CSA). 1988. Photodocumentation survey of Pulley Ridge Area Block 799, eastern Gulf of Mexico. Report prepared for Mobil Exploration & Producing U.S., Inc, New Orleans, LA. 37 pp.

Continental Shelf Associates, Inc. (CSA). 1990. Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the south Florida area. U.S. Dept of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 90-0019. 727 pp.

Continental Shelf Associates, Inc. (CSA). 1992a. Mississippi-Alabama shelf pinnacle trend habitat mapping study. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0026. 114 pp. + 2 plates.

Continental Shelf Associates, Inc. (CSA). 1992b. Preliminary report of potential effects of oil spilled from Texaco's proposed pipeline from Platform A in Garden Banks Block 189 to the subsea tie-in with High Island Pipeline System's (HIPS) existing pipeline in High Island Area Block A-377 (modified route). Prepared for Texaco Pipeline, Inc., Jupiter, FL.

Continental Shelf Associates, Inc. (CSA). 1994. Analysis of potential effects of oil spilled from proposed structures associated with Oryx's High Island Block 384 unit on the biota of the East Flower Garden Bank and on the biota of Coffee Lump Bank. Prepared for Oryx Energy Company, Jupiter, FL.

Continental Shelf Associates, Inc., (CSA). 1997a. Radionuclides, metals, and hydrocarbons in oil and gas operational discharges and environmental samples associated with offshore production facilities on the Texas/Louisiana continental shelf with an environmental assessment of metals and hydrocarbons: Prepared for the U.S. Dept. of Energy, Bartlesville, OK.

Continental Shelf Associates, Inc. (CSA). 1997b. Gulf of Mexico produced water bioaccumulation study: Definitive component technical report. Prepared for the Offshore Operators Committee. 258 pp.

Continental Shelf Associates, Inc. (CSA). 2000. Deepwater Gulf of Mexico environmental and socioeconomic data search and literature synthesis. Volume I: Narrative report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-049. 340 pp.

Continental Shelf Associates, Inc. (CSA). 2004a. Geological and geophysical exploration for mineral resources on the Gulf of Mexico outer continental shelf: Final programmatic environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EA/EIS MMS 2004-054. 466 pp.

Continental Shelf Associates, Inc. (CSA). 2004b. Gulf of Mexico comprehensive synthetic based muds monitoring program: Final report. Volume II: Technical. Prepared for SMB Research Group. 358 pp. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/2/3051.pdf.

Continental Shelf Associates, Inc. (CSA). 2006a. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-045. 636 pp.

Continental Shelf Associates, Inc. (CSA). 2006b. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. Volume I: Executive Summary. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-044. 51 pp.

Continental Shelf Associates, Inc. (CSA) and Martel Laboratories, Inc. 1985. Florida Big Bend seagrass habitat study: Narrative report. U.S. Dept. of the Interior, Mineral Management Services, Gulf of Mexico Region, New Orleans, LA. OCS Study MMS 85-0088. Contract No. 14-12-0001-30188. 114 pp.

Continental Shelf Associates, Inc. (CSA) and Texas A&M University, Geochemical and Environmental Research Group (GERG). 2001. Mississippi/Alabama pinnacle trend ecosystem monitoring: Final synthesis report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-2001-0007 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-080. 415 pp. + apps.

Cook, C.B. and A.H. Knap. 1983. Effects of crude oil and chemical dispersant on photosynthesis in the brain coral *Diploria strigosa*. Marine Biology 78:21-27.

Corliss, J.B., J. Dymond, L. Gordon, J.M. Edmond, R.P. von Herzen, R.D. Ballard, K. Green, D. Williams, A. Bainbridge, K. Crane, and T.H. Van Adel. 1979. Submarine thermal springs on the Galapagos Rift. Science 203:1073-1083.

CoreLogic. 2010. New CoreLogic data shows the potential impact of the BP *Deepwater Horizon* oil spill on coastal real estate. Internet website: http://www.corelogic.com/About-Us/News/New-CoreLogic-Data-Shows-the-Potential-Impact-of-the-BP-Deepwater-Horizon-Oil-Spill-on-Coastal-Real-Estate.aspx. Accessed November 9, 2010.

Coston-Clements, L., L.R. Settle, D.E. Hoss, and F.A. Cross. 1991. Utilization of the Sargassum habitat by marine invertebrates and vertebrates, a review. U.S. Dept. of the Interior, National Marine Fisheries Service, NOAA, Southeast Fisheries Science Center, Beaufort Laboratory, Beaufort, NC. 32 pp.

Cox, S.A., E.H. Smith, and J.W. Tunnell, Jr. 1997. Macronektonic and macrobenthic community dynamics in a coastal saltmarsh: Phase I. Prepared for Texas Parks and Wildlife Dept., Wildlife Division. TAMU-CC-9701-CCS. Corpus Christi, TX. 67 pp.

Cox, J., C. Coomes, S. DiMarco, K. Donohue, G.Z. Forristall, P. Hamilton, R.R. Leben, and D.R. Watts. In Press. Study of deepwater currents in the eastern Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-041. 473 pp.

Cranswick, D. 2001. Brief overview of Gulf of Mexico OCS oil and gas pipelines: Installation, potential impacts, and mitigation measures. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2001-067. 19 pp.

Creef, E. and L. Mathies. 2002. Beneficial uses of dredged material: Part of the solution to restoration of Louisiana's coastal wetlands. In: Garbaciak, S., ed. ASCE Conference Proceedings, Dredging 2002, Key Technologies for Global Prosperity.

Cruz-Kaegi, M.E. 1998. Latitudinal variations in biomass and metabolism of benthic infaunal communities. Ph.D. Dissertation, Texas A&M University, College Station, TX.

Culter, J.K., K.B. Ricthie, S.A. Earle, D.E. Guggenheim, R.B. Halley, K.T. Ciembronowicz, A.C. Hine, B.D. Jarrett, S.D. Locker, W.C. Jaap. 2005. Pulley Reef: A deep photosynthetic coral reef on the West Florida Shelf, USA. 1 p. Springer-Verlag. Coral Reefs (2006) DOI 10.1007/s00338-006-0097-6. Internet website: http://isurus.mote.org/Keys/microbiology/CRPulfinal.pdf. Accessed December 17, 2010.

Cummins, J.L. 2005. The federal role in restoring private forest land after Hurricane Katrina. 10 pp. Internet website: http://www.growthevote.org/afpa/HouseResourcesCommitteeTestimony-Cummins.pdf. Accessed September 2006.

Cutter, S.L., L. Barnes, M. Berry, C.G. Burton, E. Evans, E.C. Tate, and J. Webb. 2008. Community and regional resilience: Perspectives from hazards, disasters, and emergency management. CARRI Research Report 1. Oak Ridge, TN: Community and Regional Resilience Institute. 33 pp. Internet website: http://www.resilientus.org/library/FINAL_CUTTER_9-25-08_1223482309.pdf. Accessed February 16, 2011.

Dahl, T.E. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. 21 pp.

Dalton, M.S. and S.A. Jones, comps. 2010. Southeast regional assessment project for the National Climate Change and Wildlife Science Center, U.S. Geological Survey. U.S. Dept. of the Interior, Geological Survey, Reston, VA. Open-File Report 2010–1213. v + 38 pp. Internet website: http://serap.er.usgs.gov/docs/SerapOFR2010_1213.pdf.

Dames & Moore, Inc. 1979. Mississippi, Alabama, Florida outer continental shelf baseline environmental survey; MAFLA, 1977/78. Volume I-A. Program synthesis report. U.S. Dept. of the Interior, Bureau of Land Management, Washington, DC. BLM/YM/ES-79/01-Vol-1-A. 278 pp.

Dauterive, L.D. 2000. Rigs-to-Reefs policy, progress, and perspective. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2000-073. 8 pp.

Davidson, C. 2010. The Gulf Coast cleans up: Oil spill seeps into many coastal concerns. EconSouth, third quarter. Federal Reserve Bank of Atlanta, Atlanta, GA. 5 pp. Internet website: http://www.frbatlanta.org/documents/pubs/econsouth/10_q3_oil_spill.pdf.

Davis, H.C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biological Bulletin, Marine Biological Laboratory 114(3):296-307.

Davis, R.W. and G.S. Fargion, eds. 1996. Distribution and abundance of cetaceans in the north-central western Gulf of Mexico: Final report. Volume II: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0027. 355 pp.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003. 346 pp.

Davis, B., D.S. Etkin, M. Landry, and K. Watts. 2004. Determination of oil persistence: A historical perspective. In: Proceedings, Fifth Biennial Freshwater Spills Symposium. Internet website: http://www.environmental-research.com/erc_papers/ERC_paper_19.pdf.

Dawes, C.J., J. Andorfer, C. Rose., C. Uranowski, and N. Ehringer. 1997. Regrowth of seagrass *Thalassia testudinum* into propeller scars. Aquatic Botany 59:139-155.

Dawes, C.J., R.C. Phillips, and G. Morrison. 2004. Seagrass communities of the Gulf Coast of Florida: Status and ecology. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute and the Tampa Bay Estuary Program, St. Petersburg, FL. iv + 74 pp. Internet website: http://gulfsci.usgs.gov/gom_ims/pdf/pubs_fl.pdf.

De Leon, M.T. and L.M. Smith. 1999. Behavior of migrating shorebirds at North Dakota prairie potholes. Condor 101:645-654.

Dean, T.A. and S.C. Jewett. 2001. Habitat-specific recovery of shallow subtidal communities following the *Exxon Valdez* oil spill. Ecological Applications 11(5):1456-1471.

DeCort, T. 2010. Personal communication. Gas release estimate for *Macondo*. September 14, 2010. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico OCS Region, Resource Evaluation, New Orleans, LA.

Defenbaugh, R.E. 1976. A study of the benthic macroinvertebrates of the continental shelf of the northern GOM. Unpublished Ph.D. dissertation, Texas A&M University, College Station, TX. 476 pp.

DeLaune, R.D., W.H. Patrick, and R.J. Buresh. 1979. Effect of crude oil on a Louisiana *Spartina alterniflora* salt marsh. Environmental Pollution 20:21-31.

DeLaune, R.D., R.P. Gambrell, J.H. Pardue, and W.H. Patrick, Jr. 1990. Fate of petroleum hydrocarbons and toxic organics in Louisiana coastal environments. Estuaries 132(1):72-80.

Deleersnijder, E., J.M. Beckers, , and E.J.M. Delhez. 2006. The residence time of settling particles in the surface mixed layer. Environmental Fluid Mechanics 6:25-42.

Deming, J. and J. Baross. 1993. The early diagenesis of organic matter: Bacterial activity. In: Engel, M. and S. Macko, eds. Organic geochemistry. New York, NY: Plenum. Pp. 119-144.

den Hartog, C. and R.P.W.M. Jacobs. 1980. Effects of the "Amoco Cadiz" oil spill on an eelgrass community at Roscoff (France) with special reference to the mobile benthic fauna. Helgoländer Meeresunters 33:182-191.

Dennis, G.D. and T.J.Bright. 1988. Reef fish assemblages on hard banks in the northwestern Gulf of Mexico. Bulletin of Marine Science 43(2):280-307.

Denson, C. 2010. Personal communication. Fish kills in Mobile Bay. Alabama Dept. of Environmental Management. September 28, 2010.

Devers, W. 2010. Written communication. Email regarding Mississippi fish kill summary and Long Beach fish kill. Marine Fisheries Scientist, Mississippi Dept. of Marine Sciences. September 27, 2010.

Di Silvestro, R. 2006. When hurricanes hit habitat. National Wildlife Magazine. Aug/Sep 2006 44(5):5 pp.

Diaz, R.J. and A. Solow. 1999. Ecological and economic consequences of hypoxia. Topic 2 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. U.S. Dept. of Commerce, NOAA Coastal Ocean Program, Silver Spring, MD. NOAA Coastal Ocean Program Decision Analysis Series No. 16. 45 pp.

Digital Petrodata. 2010. Digital Petrodata. Internet website: http://www.scribd.com/doc/29413777/4-2010-Digital-Petrodata-BLM-STATE-MMS-Oil-Gas-Lease-Sale-Auction-2010-April. Accessed November 30, 2010.

Dinsdale, E.A. and V.J. Harriot. 2004. Assessing anchor damage on coral reefs: A case study in selection of environmental indicators. Environmental Management 33(1):126-139.

Dismukes, D.E. 2010a. Personal communication. More conservative scenario. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. September 29, 2010.

Dismukes, D.E. 2010b. Personal communication. Gas processing. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. October 20, 2010.

Dismukes, D.E. 2010c. Personal communication. Pipeline landfalls. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. October 26, 2010.

Dismukes, D.E. 2010d. Personal communication. Waste disposal. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. November 23, 2010.

Dismukes, D.E. 2010e. Personal communication. E-mail entitled GOM employment observations. Associate Director, Louisiana State University, Center for Energy Studies, Baton Rouge, LA. December 8, 2010.

Dismukes, D.E. In preparation-a. Fact book: OCS-related energy infrastructure and post-hurricane impact assessment. U.S. Dept. of the Interior, Bureau of Ocean Energy, Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA.

Dismukes, D.E. In preparation-b. Fact book: Offshore oil and gas industry support sectors. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-042.

Dismukes, D.E., M. Barnett, D. Vitrano, and K. Strellec. 2007. Gulf of Mexico OCS oil and gas scenario examination: Onshore waste disposal. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2007-051. 5 pp.

Dloughy, J.A. 2010. Government gives notice on abandoned platforms: Rule tells industry to dismantle 'idle iron' and plug old oil, gas wells. *Houston Chronicle*, September 15, 2010. Internet website: http://www.reefrelieffounders.com/drilling/2010/09/16/houston-chroniclegovernment-gives-notice-on-abandoned-platforms-rule-tells-industry-to-dismantle-idle-iron-and-plug-old-oil-gas-wells-dont-blame-bp-alone-for-spill-hayward/. Accessed March 1, 2011.

Dobbs, C.D. and J.M. Vozarik. 1983. Immediate effects of a storm on coastal infauna. Marine Ecology Progress Series 11:273-279.

Dodge, R.E., R.C. Aller, and J. Thomson. 1974. Coral growth related to resuspension of bottom sediments. Nature 247:574-577.

Dodge, R.E., S.C. Wyers, A.H. Knap, H.R. Frith, T.D. Sleeter, and S.R. Smith. 1984. The effects of oil and oil dispersants on hermatypic coral skeletal growth (extension rate). Coral Reefs 3:191-198.

Doe, K.G. and P.G. Wells. 1978. Acute toxicity and dispersing effectiveness of oil spill dispersants: results of a Canadian oil dispersant testing program (1973 to 1977). In: McCarthy, Jr., L.T., G.P. Lindblom, and H.F. Walter, eds. Chemical dispersants for the control of oil spills. Philadelphia, PA: American Society for Testing and Materials. Pp. 50-65.

Dokka, R. 2006. Modern-day tectonic subsidence in coastal Louisiana. Geology 34(4):281-284.

Dokka, R.K., G.F. Sella, and T.H. Dixon. 2006. Tectonic control of subsidence and southward displacement of southeast Louisiana with respect to stable North America. American Geophysical Union, Geophysical Research Letters Volume 33, L23308. Internet website: http://www.ngs.noaa.gov/CORS/Articles/2006GL027250.pdf.

Donato, K.M. 2004. Labor migration and the deepwater oil industry. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-057. 125 pp.

Donato, K.M., D.T. Robinson, and C.L. Bankston III. 1998. To have them is to love them: Immigrant workers in the offshore industry. Paper read at the Annual Meeting of the Latin American Studies Association, Chicago, IL, September 1998. 18 pp. (unnumbered Xerox).

Donohue, K., P. Hamilton, R. Leben, R.Watts, and E. Waddell. 2008. Survey of deepwater currents in the northwestern Gulf of Mexico. Volume II: Technical report. U.S. Dept. ofthe Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans,LA. OCS Study MMS 2008-031. 375 pp.

Dooley, J.K. 1972. Fishes associated with the pelagic Sargassum complex, with a discussion of the Sargassum community. Contrib. Mar. Science. 16:1-32.

Doran, K.S., N.G. Plant, H.F. Stockdon, A.H. Sallenger, and K.A. Serafin. 2009. Hurricane Ike: Observations of coastal change. U.S. Dept. of the Interior, Geological Survey, Reston, VA. Open-File Report 2009-1061. vi + 35 pp. Internet website: http://pubs.usgs.gov/of/2009/1061/pdf/ofr2009-1061.pdf.

Douglass, S.L., T.A. Sanchez, and S. Jenkins. 1999. Mapping erosion hazard areas in Baldwin County, Alabama, and the use of confidence intervals in shoreline change analysis. Journal of Coastal Research SI (28):95-105.

Dovel, W.L., A.W. Pekovitch, and T.J. Berggren. 1992. Biology of the shortnose sturgeon (*Acipenser brevirostrum* Lesueur, 1818) in the Hudson River estuary. In: Smith, C.L., ed. Estuarine research in the 1980's. Albany, NY: State University of New York Press.

Drewitt, A.L. and R.H.W. Langston. 2008. Collision effects of wind-power generators and other obstacles on birds. Annals of the New York Academy of Sciences 1134:233266.

Driver, A. 2010. Helix readying Gulf oil spill containment system. Reuters. December 8, 2010. Internet website: http://www.reuters.com/article/2010/12/08/spill-helix-idUSN0818292520101208. Accessed December 27, 2010.

Duarte, C.M., J.J. Middelburg, and N. Caraco. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences 2:1-8.

Dubois, S., C.G. Gelpi Jr., R.E. Condrey, M.A. Grippo, and J.W. Fleeger. 2009. Diversity and composition of macrobenthic community associated with sandy shoals of the Louisiana continental shelf. Biodiversity and Conservation 18(14):3759-3784.

Ducklow, H.W. and R. Mitchell. 1979. Composition of mucus released by coral reef Coelenterates. Limnology and Oceanography 24(2):706-714.

Dunne, R. and E. Miller. 2007. Post-release survival of oiled, rehabilitated waterfowl. In: Massey, J.G., ed. Proceedings of the Ninth International Effects of Oil on Wildlife Conference, Monterey, CA, 2007, University of California at Davis Wildlife Health Center, Davis.

Dunton, K.H., S.V. Shonberg, S. Herzka, P.A. Montagna, and S.A. Holt. 1998. Characterization of anthropogenic and natural disturbance on vegetated and nonvegetated bay bottom habitats in the Corpus Christi Bay National Estuarine Program Study Area. Volume II: Assessment of scarring in seagrass beds. CCBNEP-25B. 23 pp.

Durako, M.J., M.O. Hall, F. Sargent, and S. Peck. 1992. Propeller scars in sea grass beds: An assessment and experimental study of recolonization in Weedon Island State Preserve, Florida. In: Web, F., ed. Proceedings, 19th Annual Conference of Wetland Restoration and Creation. Hillsborough Community College, Tampa, FL. Pp. 42-53.

Edwards, R. 2008. Sea levels: Science and society. Progress in Physical Geography 32(5):557-574.

Edwards, R.E., K.J, Sulak, C.B. Grimes, and M. Randall. 2003. Movements of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in nearshore habitat as determined by acoustic telemetry. Gulf of Mexico Science 2003(1):59-70.

Edwards, R.E., F.M. Parauka, and K.J. Sulak. 2007. New insights into marine migration and winter habitat of Gulf sturgeon. American Fisheries Society Symposium 56:183-196.

Eggleton, J. and K.V. Thomas. 2004. A review of factors affecting the release and bioavailability of contaminants during sediment disturbance events. Environment International 30:973-980.

Ehrhart, L.M. 1978. Choctawhatchee beach mouse. In: Layne, J.N., ed. Rare and endangered biota of Florida. Volume I: Mammals. Gainesville, FL: University Presses of Florida. Pp. 18-19.

Eleuterius, L.N. 1987. Seagrass ecology along the coasts of Alabama, Louisiana, and Mississippi. Florida Marine Research Publications, No. 42. Pp. 11-24.

Elgershuizen, J.H.B.W. and H.A.M. De Kruijf. 1976. Toxicity of crude oils and a dispersant to the stony coral *Madracis mirabilis*. Marine Pollution Bulletin 7(2):22-25.

Elliott-Smith, E., S.M. Haig, and B.M. Powers. 2009. Data from the 2006 International Piping Plover Census: U.S. Geological Survey Data Series 426. 332 pp.

Ellis, M.S., E.A. Wilson-Ormond, and E.N. Powell. 1996. Effects of gas-producing platforms on continental shelf macroepifauna in the northwestern Gulf of Mexico: Abundance and size structure. Canadian Journal of Fisheries and Aquatic Science 53:2589-2605.

Ellwood, B.B., W.L. Balsam, and H.H. Roberts. 2006. Gulf of Mexico sediment sources and sediment transport trends from magnetic susceptibility measurements of surface samples. Marine Geology 230:237-248.

Elsner, J.B., T.H. Jagger, M. Dickinson, and D. Rowe. 2008. Improving multiseason forecasts of North Atlantic hurricane activity. American Meteorological Society 21:1210-1219. Internet website: http://myweb.fsu.edu/jelsner/PDF/Research/ElsnerJaggerDickinsonRowe2008.pdf.

Ely, C.R., D.H. Ward, and K.S. Bollinger. 1999. Behavioral correlates of heart rates of free-living greater white-fronted geese. Condor 101:390-395.

Emanuel, K.A. 2000. A statistical analysis of tropical cyclone intensity. Monthly Weather Review 128:1139-1152.

Emanuel, K.A. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature 436:686-688.

Emery, W.J., K. Cherkauer, B. Shannon, and RW. Reynolds. 1997. Hull-mounted sea surface temperatures from ships of opportunity. American Meteorological Society, Boston, MA. Journal of Atmospheric and Oceanic Technology 14:1237-1251.

Energo Engineering. 2010. Assessment of damage and failure mechanisms for offshore structures and pipelines in Hurricanes Gustav and Ike. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 642.

Energy Resources Co., Inc. (ERCO). 1982. Ixtoc oil spill assessment: Final report. 3 vols. Prepared for the U.S. Dept. of the Interior, Bureau of Land Management, Gulf of Mexico OCS Region, New Orleans, LA. Contract No. AA851-CTO-71. Study Nos. 1982-34, 1982-35, and 1982-37.

Engel, J. and R. Kvitek. 1998. Effects of otter trawling on a benthic community in Monterey Bay National Marine Sanctuary. Conservation Biology 12(6):1204-1214.

Engle, V.D., J.L. Hyland, and C. Cooksey. 2008. Effects of Hurricane Katrina on benthic macroinvertebrate communities along the northern Gulf of Mexico coast. Environmental Monitoring Assessment 150:193-209.

English, C. 2010. BP Gulf spill: Mississippi Canyon Block 252 crude oil analysis. Wednesday, June 9, 2010. Internet website: http://blog.restek.com/?cat=3. Accessed June 30, 2010.

Enright, J.M., R. Gearhart II, D. Jones, and J. Enright. 2006. Study to conduct National Register of Historic Places evaluations of submerged sites on the Gulf of Mexico outer continental shelf. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-036. 136 pp.

ENSR Corporation. 2004. Assessment of Alabama beach mouse habitat flooding on the Fort Morgan Peninsula using FEMA digital flood insurance rate map (DFIRM) and the Coastal Hazard Assessment Program.

Environmental Science & Research Limited. 1998. The effects of air pollution on New Zealand ecosystems: Review of national and international research: Technical report no. 1. Ministry for the Environment, New Zealand. 77 pp. Internet website: http://www.mfe.govt.nz/publications/air/research-review-jun98.pdf. Accessed February 12, 2007.

Erftemeijer, P.L.A. and R.R.R. Lewis III. 2006. Environmental impacts of dredging on seagrass: A review. Marine Pollution Bulletin 52:1553-1572.

Essink, K. 1999. Ecological effects of dumping of dredging sediments; options for management. Journal of Coastal Conservation 5(1):69-80.

Etkin, D.S. 2009. Analysis of U.S. oil spillage. American Petroleum Institute, Regulatory and Scientific Affairs Department. 86 pp. API Publication 356. Internet website: http://www.api.org/ehs/water/spills/upload/356-Final.pdf.

European Inland Fisheries Advisory Commission. 2010. Methodologies for assessing socioeconomic benefits of European inland recreational fisheries. EIFAC Occasional Paper No. 46.

European Wind Energy Association. 2011. The European offshore wind industry key trends and statistics 2010. 3 pp. Internet website: http://www.ewea.org/fileadmin/ewea_documents/documents/00_POLICY_document/Offshore_Statistics/110120_Offshore_stats_Exec_Sum.pdf.

Fabacher, D.L., J.M. Besser, C.J. Schmitt, J.C. Harshbarger, P.H. Peterman, and J.A. Lebo. 1991. Contaminated sediments from tributaries of the Great Lakes: chemical characterization and cancer-causing effects in medaka (*Oryzias latipes*). Arch. Environ. Contam. Toxic. 20:17-35.

Fanning, K., K.L. Carder, and P.R. Betzer. 1982. Sediment resuspension by coastal waters: A potential mechanism for nutrient re-cycling on the ocean's margins. Deep-Sea Research 29:953-965.

Farmer, A. and F. Durbian. 2006. Estimating shorebird numbers at migration stopover sites. Condor 108:792-807.

Fauchald, K. and P.A. Jamurs. 1979. The diet of worms: A study of polychaete feeding guilds. Oceanography and Marine Biology: An Annual Review 17:193-284.

Federal Register. 1993. Oil and gas extraction point source category; offshore subcategory effluent guidelines and new source performance standards. Final rule. March 4, 1993. 58 FR 12454.

Federal Register. 1997a. Hydrogen sulfide requirements for operations in the outer continental shelf. Final rule. 62 FR 17, pp. 3793-3800. Internet website: http://www.boemre.gov/federalregister/PDFs/h2sfr.pdf.

Federal Register. 1997b. Blowout preventer (BOP) testing requirements for drilling and completion operations. Proposed rule. July 15, 1997. 62 FR 135, pp. 37819-37824. Internet website: http://www.boemre.gov/federalregister/PDFs/BOPTesting.PDF.

Federal Register. 1998. Blowout preventer (BOP) testing requirements for drilling and completion operations. Final rule. June 1, 1998. 63 FR 104, pp. 29604-29608. Internet website: http://www.boemre.gov/federalregister/PDFs/Bop.pdf.

Federal Register. 1999. Rules and regulations, Department of the Interior, Fish and Wildlife Service 50 CFR Part 17: Endangered and threatened wildlife and plants; removal of the American peregrine falcon from the Federal list of endangered and threatened wildlife and removal of the similarity of appearance provision for free-flying peregrines in the conterminous United States. Final rule. August 25, 1999. 64 FR 164, pp. 46542-46558.

Federal Register. 2001. Rules and regulations, Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17: Endangered and threatened wildlife and plants; final determinations of critical habitat for wintering piping plovers. Final rule. July 10, 2001. 66 FR 132, pp. 36037-36086.

Federal Register. 2006a. Oil and gas and sulphur in the outer continental shelf (OCS)—Safety and Environmental Management Systems. Advanced notice of proposed rule. 71 FR 98, pp. 29277-29280. Internet website: http://edocket.access.gpo.gov/2006/pdf/E6-7790.pdf.

Federal Register. 2006b. Oil and gas and sulphur operations in the outer continental shelf—Incident reporting requirements. Final rule. 71 FR 73, pp. 19640-19646. Internet website: http://www.boemre.gov/federalregister/PDFs/AC57-4-17-06.pdf.

Federal Register. 2007. Rules and regulations, Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17: Endangered and threatened wildlife and plants; removal of the bald eagle from the federal list of endangered and threatened wildlife. Final rule. July 9, 2007. 72 FR 130, pp. 37346-37372.

Federal Register. 2008. Record of decision for the final programmatic environmental impact statement for alternative energy development and production and alternate use of facilities on the outer continental shelf. January 10, 2007. 73 FR 7, pp. 1894-1895.

Federal Register. 2009a. Safety and environmental management systems for outer continental shelf oil and gas operations. Proposed rule. 74 FR 115, pp. 28639-28654. Internet website: http://www.gpo.gov/fdsys/pkg/FR-2009-06-17/pdf/E9-14211.pdf.

Federal Register. 2009b. Renewable energy and alternate uses of existing facilities on the outer continental shelf. Final rule. April 29, 2009. 74 FR 81, pp. 19638-19871.

Federal Register. 2009c. Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; reef fish fishery of the Gulf of Mexico; Gulf reef fish longline restriction. May 1, 2009. 74 FR 83, pp. 20229-20230. Internet website: http://frwebgate2.access.gpo.gov/cgi-bin/PDFgate.cgi?WAISdocID=KK4pFy/2/2/0&WAISaction=retrieve. Accessed May 18, 2011.

Federal Register. 2009d. Rules and regulations, Department of the Interior Fish and Wildlife Service 50 CFR Part 17: Endangered and threatened wildlife and plants; removal of the brown pelican (*Pelecanus occidentalis*) from the federal list of endangered and threatened wildlife. Final rule. November 17, 2009. 74 FR 220, pp. 59443-59472.

Federal Register. 2010a. Oil and gas and sulphur operations in the outer continental shelf—Safety and environmental management systems. Final rule. 75 FR 63610-63654. Internet website: http://www.gpo.gov/fdsys/pkg/FR-2010-10-15/pdf/2010-25665.pdf.

Federal Register. 2010b. Oil and gas and sulphur operations in the outer continental shelf—Increased safety measures for energy development on the outer continental shelf. Interim final rule. 75 FR 198, pp. 63346-63377. Internet website: http://www.gpo.gov/fdsys/pkg/FR-2010-10-14/pdf/2010-25256.pdf.

Federal Register. 2010c. Outer Continental Shelf (OCS),Western and Central Planning Areas, Gulf of Mexico (GOM) oil and gas lease sales for the 2007-2012 5-Year OCS Program. November 10, 2010. 75 FR 217, pp. 69122-69123.

Federal Register. 2010d. Outer Continental Shelf (OCS), Western and Central Planning Areas, Gulf of Mexico (GOM) oil and gas lease sales for the 2007-2012 5-Year OCS Program. November 16, 2010. 75 FR 220, pp. 70023-70024.

Federal Register. 2010e. Approval and promulgation of air quality implementation plans; Louisiana; Baton Rouge 8-hour ozone nonattainment area; determination of attainment of the 8-hour ozone standard. Final rule. 75 FR 174, pp. 54778-54779. Internet website: http://edocket.access.gpo.gov/2010/pdf/2010-22338.pdf. Accessed May 11, 2011.

Federal Register. 2010f. Listing endangered and threatened wildlife and plants; 90-day finding on a petition to list bluefin tuna as threatened or endangered under the Endangered Species Act. Proposed rule. 50 CFR 223 and 224. Tuesday, September 21, 2010.

Federal Register. 2010fg Cancellation of oil and gas Lease Sale 215 in the Western Planning Area on the outer continental shelf in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement. July 28, 2010. 75 FR 144, p. 44276. Internet website: http://edocket.access.gpo.gov/2010/pdf/2010-18425.pdf.

Federal Reserve Bank of Atlanta. 2010. Gulf oil spill updates: July 21, 2010. Internet website: http://www.frbatlanta.org/rein/rein-resources/econ-impacts/gulfspill/2010-07-21.cfm. Accessed December 15, 2010.

Feldman, S. 2009. China beats US to offshore wind development. Internet website: http://solveclimate.com/news/20090403/china-beats-us-offshore-wind-development. Posted April 3, 2009. Accessed March 23, 2011.

Fenner, D. and K. Banks. 2004. Orange cup coral *Tubastraea coccinea* invades Florida and the Flower Garden Banks, northwestern Gulf of Mexico. Coral Reefs 23(4):505-507.

Field, J.C., D.F. Boesch, D. Scavia, R. Buddemeier, V.R. Burkett, and D. Cayan. 2001. Potential consequences of climate variability and change on coastal areas and marine resources. In: Climate change impacts on the United States. New York: Cambridge University Press.

Fingas, M. 1995. Oil spills and their cleanup. Chemistry and Industry. Internet website: http://findarticles.com/p/articles/mi_hb5255/is_n24/ai_n28664618/. Accessed December 23, 2010.

Fingas, M., F. Ackerman, P. Lambert, K. Li, Z. Wang, J. Mullin, L. Hannon, D. Wang, A. Steenkammer, R. Hiltabrand, R. Turpin, and P. Campagna. 1995. The Newfoundland offshore burn experiment: Further results of emissions measurement. In: Proceedings of the Eighteenth Arctic and Marine Oilspill Program Technical Seminar, Volume 2, June 14-16, 1995, Edmonton, Alberta, Canada. Pp. 915-995.

Fire in the Ice. 2009. Gulf of Mexico gas hydrate drilling and logging expedition underway. U.S Dept. of Energy, National Energy Technology Laboratory, Methane Hydrate Newsletter. Spring 2009. Pp. 1-10. Internet website: http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/Newsletter/MHNewsSpring09.pdf#Page=1.

Fischel, M., W. Grip, and I.A. Mendelssohn. 1989. Study to determine the recovery of a Louisiana marsh from an oil spill. In: Proceedings, 1989 Oil Spill Conference. February 13-16, 1989, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 383-387.

Fisher, C.R. 1995. Characterization of habitats and determination of growth rate and approximate ages of the chemosynthetic symbiont-containing fauna. In: MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. 1995. Chemosynthetic ecosystems study: Final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. Pp. 5.1-5.47.

Fisher, M. 2010. Personal communication. Fish kills in Texas and effects of BP spill on Texas oysters. Texas Parks and Wildlife Department. Texas Parks and Wildlife Department, Rockport Marine Lab. August 6, 2010.

Fisher, W.L., L.F. Brown, Jr., J.H. McGowen, and C.G. Groat. 1973. Environmental geologic atlas of the Texas coastal zone: Beaumont-Port Arthur area. Austin, TX: The University of Texas at Austin, Bureau of Economic Geology.

Fisher, C.R., I. Urcuyo, M.A. Simpkins, and E. Nix. 1997. Life in the slow lane: Growth and longevity of cold-seep vestimentiferans. Marine Ecology 18:83-94.

Flemer, D.A., B.F. Ruth, and C.M. Bundrick. 2002. Effects of sediment type on macrobenthic infaunal colonization of laboratory microcosoms. Hydrobiologia 485:83-96.

Florida A&M University. 1988. Meteorological database and synthesis for the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0064. 430 pp.

Florida Dept. of Environmental Protection and U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. 2000. Final restoration plan/environmental assessment for the August 10, 1993 Tampa Bay oil spill. Volume 2: Human use and recreational injuries. 52 pp.

Florida Fish and Wildlife Conservation Commission. 2008. FAQs: Sea turtles and hurricanes. Internet website: http://myfwc.com/Newsroom/Resources/News_Resources_SeaTurtlesAndHurricanes.htm. Accessed September 5, 2008.

Florida Fish and Wildlife Conservation Commission. 2010a. Index nesting beach survey totals (1989-2010). Internet website: http://www.myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals-1989-2010/. Accessed April 13, 2011.

Florida Fish and Wildlife Conservation Commission. 2010b. A good nesting season for loggerheads in 2010 does not reverse a recent declining trend. Internet website: http://www.myfwc.com/research/wildlife/sea-turtles/nesting/2010/. Accessed April 13, 2011.

Florida Fish and Wildlife Conservation Commission. 2010c. Saltwater fishing regulations. Internet website: http://myfwc.com/fishing/saltwater/regulations/. Accessed April 15, 2011.

Florida Fish and Wildlife Conservation Commission. 2011. Manatee synoptic surveys. Internet website: http://www.fwc.state.fl.us/research/manatee/projects/population-monitoring/synoptic-surveys/. Accessed May 20, 2011.

Flowers, H.J. and W.E. Pine. 2008. Observation of a juvenile Gulf sturgeon in the Santa Fe River, Florida. Southeastern Naturalist 7:559-561.

Foley, B. 2010. Impact of fishing on shipwrecks: In: Archaeology in deep water. Woods Hole Oceanographic Institution, Woods Hole, MA. Internet website: http://www.whoi.edu/sbl/liteSite.do?litesiteid=2740&articleId=4965. Accessed August 31, 2010.

Ford, B., A. Borgens, W. Bryant, D. Marshall, P. Hitchcock, C. Arias, and D. Hamilton. 2008. Archaeological excavation of the Mardi Gras shipwreck (16GM01), Gulf of Mexico continental slope. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-037. 313 pp.

Fourqurean, J.W. and L.M. Rutten. 2004. The impact of Hurricane Georges on soft-bottom, back reef communities: Site-and species-specific effects in south Florida seagrass beds. Bulletin of Marine Science 75(2):239-257.

Fowler, G.S., J.C. Wingfield, and P.D. Boersma. 1995. Hormonal and reproductive effects of low levels of petroleum fouling in Magellanic penguins (*Spheniscus magellancus*). Auk 112:382-389.

Fox, D.A. and J.E. Hightower. 1998. Gulf sturgeon estuarine and nearshore marine habitat use in Choctawhatchee Bay, Florida. Annual Report for 1998 to the U.S. Dept. of Commerce, National Marine Fisheries Service and the U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 29 pp.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee River System, Alabama-Florida. Transactions of the American Fisheries Society 129:811-826.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2002a. Estuarine and nearshore marine habitat use by Gulf sturgeon from the Choctawhatchee River System, Florida. American Fisheries Society Symposium 28:111-126.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2002b. Estuarine and nearshore marine habitat use by Gulf sturgeon from the Choctawhatchee River System, Florida. American Fisheries Society Symposium 00:19-34.

Frank, D.J., W. Sackett, R. Hall, and A. Fredericks. 1970. Methane, ethane, and propane concentrations in the Gulf of Mexico. American Association of Petroleum Geologist Bulletin 54:1933-1938.

Fraser G.S. and J. Ellis. 2008. Offshore hydrocarbon and synthetic hydrocarbon spills in eastern Canada: The issue of follow-up and experience. Journal of Environmental Assessment Policy and Management 10(2):173-187. June 2008.

Fraser, G.S., J. Russell, and W.M. von Zharen. 2006. Produced water from offshore oil and gas installations on the Grand Banks, Newfoundland and Labrador: Are the potential effects to seabirds sufficiently known? Marine Ornithology 34:147-156.

Frater, B. 2010. Personal communication. Possible impact of cleanup relating to the *Deepwater Horizon* incident on possible beach mouse habitat in Florida. Biologist, U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services Office, Panama City, FL. October 19, 2010.

Frazier, D.E. 1967. Recent deltaic deposits of the Mississippi River: Their development and chronology. In: Sandridge, J.R., ed. Transactions Gulf Coast Association of Geological Societies, San Antonio, TX, 27:287-315. Internet website: http://search.datapages.com/data/gcags/data/017/017001/pdfs/0287.pdf.

Frazier, T.J., N.Wood, B. Yarnal, and D.H. Bauer. 2010. Influence of potential sea level rise on societal vulnerability to hurricane storm-surge hazards, Sarasota County, Florida. Applied Geography 30:490-505.

Freese, L., P.J. Auster, J. Heifetz, and B.L. Wing. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Marine Ecology Progress Series 182:119-126.

French-McCay, D.P. 2004. Oil spill impact modeling: Development and validation. Environmental Toxicology and Chemistry 23(10):2441-2456.

Frid, A. and L.M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6:11. Internet website: http://www.consecol.org/vol6/iss1/art11/.

Frithsen, J.B., R. Elmgren, and D.T. Rudnick. 1985. Responses of benthic meiofauna to long-term, low-level additions of No. 2 fuel oil. Marine Ecology Progress Series 23:1-14.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Dept. of the Interior, Fish and Wildlife Service, Division of Biological Services, Washington, DC. FWS/OBS-82/65. 455 pp.

Fry, D.M., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Archives of Environmental Contamination and Toxicology 15:453-463.

Fry, D.M., S.I. Fefer, and L. Sileo. 1987. Ingestion of plastic debris by laysan albatross and wedge-tailed shearwaters in the Hawaiian islands. Marine Pollution Bulletin 18(6B):339-343.

Fucik, K.W., T.J. Bright, and K.S. Goodman. 1984. Measurements of damage, recovery, and rehabilitation of coral reefs exposed to oil. In: Cairns, J. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers. 1984.

Fucik, K.W., K.A. Carr, and B.J. Balcom. 1995. Toxicity of oil and dispersed oil to the eggs and larvae of seven marine fish and invertebrates from the Gulf of Mexico. In: Lane, P., ed. The use of chemicals in oil spill response. STP 1252. Ann Arbor, MI. Pp. 135-171.

Gabe, T., G. Falk, M. McCarty, and V.W. Mason. 2005. Hurricane Katrina: Social-demographic characteristics of impacted areas; November 4, 2005. Congressional Research Service Report for Congress. 35 pp. Internet website: http://gnocdc.s3.amazonaws.com/reports/crsrept.pdf. Accessed February 17, 2011.

Gagliano, S.M. 1999. Faulting, subsidence and land loss in coastal Louisiana. In: Louisiana Coastal Wetlands Conservation and Restoration Task Force and Wetlands Conservation and Restoration Authority, Coast 2050: Toward a Sustainable Coastal Louisiana, Appendix B—Technical methods, Louisiana Dept. of Natural Resources, Baton Rouge, LA.

Gagliano, S.M. 2005a. Effects of earthquakes, fault movements, and subsidence on the south Louisiana landscape. Reprinted from The Louisiana Civil Engineer, Journal of the Louisiana Section of The American Society of Civil Engineers, Baton Rouge, LA. February 2005, 13(2):5-7, 19-22. Internet website: http://www.coastalenv.com/EffectofEarthquakeFaultMovementsandSubsidence.pdf.

Gagliano, S.M. 2005b. Effects of natural fault movement on land submergence in coastal Louisiana. Proceedings, 14th Biennial Coastal Zone Conference, New Orleans, LA, July 17-21, 2005. 5 pp.

Gallaway, B.J. 1981. An ecosystem of oil and gas development on the Texas-Louisiana continental shelf. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, DC. FWS/OBS-81/27. 89 pp.

Gallaway, B.J. and G.S. Lewbell. 1982. The ecology of petroleum platforms in the northwestern Gulf of Mexico: A community profile. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, DC. FWS/OBS-82/27. Bureau of Land Management, Gulf of Mexico OCS Regional Office, New Orleans, LA. Open-File Report 82-03. xiv + 92 pp.

Gallaway, B.J. and M.C. Kennicutt II. 1988. Chapter 2. The characterization of benthic habitats of the northern Gulf of Mexico. In: Gallaway, B.J., ed. Northern Gulf of Mexico continental slope study, final report: Year 4. Vol. II: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 88-0053. Pp. 2-1 to 2-45.

Gallaway, B.J., L.R. Martin, and R.L. Howard, eds. 1988. Northern Gulf of Mexico continental slope study, annual report: Year 3. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0060. 586 pp.

Gallaway, B.J., J.G. Cole, and R.G. Fechhelm. 2003. Selected aspects of the ecology of the continental slope fauna of the Gulf of Mexico: A synopsis of the northern Gulf of Mexico continental slope study, 1983-1988. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-072. 44 pp.

Ganning, B., D.J. Reish, and D. Straughan. 1984. Recovery and restoration of rocky shores, sandy beaches, tidal flats, and shallow subtidal bottoms impacted by oil spill. In: Cairns, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA.

Gardner, J.V., L.A. Mayer, J.E. Hughes Clarke, and A. Kleiner. 1998. High-resolution multibeam bathymetry of East and West Flower Gardens and Stetson Banks, Gulf of Mexico. Gulf of Mexico Science 16:131-143.

Gardner, J.V., P. Darnell, and K.J. Sulak. 2002a. Multibeam mapping of the pinnacles region, Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey. Open File Report 02-006. Internet website: http://geopubs.wr.usgs.gov/open-file/of02-006/. Accessed September 20, 2010.

Gardner, J.V., J.D. Beaudoin, J.E. Hughes Clarke, and P. Dartnell. 2002b. Multibeam mapping of selected areas of the outer continental shelf, northwestern Gulf of Mexico—Data, images, and GIS. U.S. Dept. of the Interior, Geological Survey. Open File Report 02-411. Internet website: http://geopubs.wr.usgs.gov/open-file/of02-411/index.html. Accessed September 9, 2010.

Garrison, E.G., C.P. Giammona, F.J. Kelly, A.R. Tripp, and G.A. Wolf. 1989. Historic shipwrecks and magnetic anomalies of the northern Gulf of Mexico: Reevaluation of archaeological resource management. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0024. 241 pp.

Garza, M.D., A. Prada, M. Marela and M.X. Vasquez Rodruguez. 2009. Indirect assessment of economic damages from the *Prestige* oil spill: Consequences for liability and risk prevention. Disasters 2009.

Gaston, G.R., C.F. Rakocinski, S.S. Brown, and C.M. Cleveland. 1998. Trophic function in estuaries: Response of macrobenthos to natural and contaminant gradients. Marine and Freshwater Research. 49:833-846.

Gearhart II, R., D. Jones, A. Borgens, S. Laurence, T. DeMunda, and J. Shipp. In press. Impacts of recent hurricane activity in historic shipwrecks in the Gulf of Mexico outer continental shelf. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-003.

Gentner, B. and S. Steinback. 2008. The Economic contribution of marine angler expenditures in the United States, 2006. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS F/SPO-94.

Gentner Consulting Group. 2010. Economic impacts of recreational fishing closures resulting from the *Deep Horizon* oil spill: Preliminary estimates. Internet website: http://www.keepamericafishing.org/-/pdf/econimpactsgulfoil2.pdf.

Geoscience Earth & Marine Services, Inc. 2005. Integrated study of the Great White Development Area, Blocks 813, 814, 857, and 858, Alaminos Canyon Area, Gulf of Mexico. Report for Shell Offshore, Inc. Project No. 0105-945d.

Georgi, A. 1993. The status of Kootenai River white sturgeon. Report of Don Chapman Consultants, Inc. to Pacific Northwest Utilities Conference Committee, Portland, OR.

Geraci, J.R. and D.J. St. Aubin. 1980. Offshore petroleum resource development and marine mammals: A review and research recommendations. Marine Fisheries Review 42:1-12.

Geraci, J.R. and D.J. St. Aubin, eds. 1990. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. 282 pp.

Getter, C.D., G. Cintron, B. Kicks, R.R. Lewis III, and E.D. Seneca. 1984. The recovery and restoration of salt marshes and mangroves following an oil spill. In: Cairn, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers, Ann Arbor Science Book. Pp. 65-104.

Gibson, D.J., and P.B. Looney. 1994. Vegetation colonization of dredge spoil on Perdido Key, Florida. Journal of Coastal Research 10:133-134.

Gilbert, D. 2011. New scrutiny slams near shore exploration. *The Wall Street Journal*. Internet website: http://online.wsj.com/article/SB10001424052970204204004576050442684314836.html?KEYWORDS=new+scrutiny+slams+near-shore+exploration. Posted January 3, 2011. Accessed January 4, 2011.

Gill, J.A., K. Norris, and W.J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Gitschlag, G.R., J.S. Schrripa, and J.E. Powers. 2000. Estimation of fisheries impacts due to underwater explosives used to sever and salvage oil and gas platforms in the U.S. Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-087. 80 pp.

Gittings, S.R. 1998. Reef community stability on the Flower Garden Banks, northwest Gulf of Mexico. Gulf of Mexico Science 16(2):161-169.

Gittings, S.R., comp. 2006. Conservation science in NOAA's National Marine Sanctuaries: Description and recent accomplishments. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. Marine Sanctuaries Conservation Series ONMS-06-04. 30 pp. Internet website: http://sanctuaries.noaa.gov/science/conservation/pdfs/accomplishments.pdf.

Gittings, S.R., T.J. Bright, W.W. Schroeder, W.W. Sager, J.S. Laswell, and R. Rezak. 1992a. Invertebrate assemblages and ecological controls on topographic features in the northeast Gulf of Mexico. Bulletin of Marine Science 50(3):435-455.

Gittings, S.R., G.S. Boland, K.J.P. Deslarzes, D.K. Hagman, and B.S. Holland. 1992b. Long-term monitoring at the East and West Flower Garden Banks. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0006. 206 pp.

Gittings, S.R., G.S. Boland, K.J.P. Deslarzes, C.L. Combs, B.S. Holland, and T.J. Bright. 1992c. Mass spawning and reproductive viability of reef corals at the East Flower Garden Bank, northwest Gulf of Mexico. Bulletin of Marine Science 51(3):420-428.

Gittings, S.R., G.S. Boland, C.R.B. Merritt, J.J. Kendall, K.J.P. Deslarzes, and J. Hart. 1994. Mass spawning by reef corals in the Gulf of Mexico and Caribbean Sea. A Report on Project Reef Spawn '94. Flower Gardens Fund Technical Series Report Number 94-03.

Gobert, A. 2010. OCS pipelines (DOT jurisdiction) that terminate onshore Louisiana. Excel spreadsheet provided by Angie Gobert, Field Operations, to Perry Boudreaux, Leasing and Environment, Gulf of Mexico Region, Bureau of Ocean Energy Management, Regulation and Enforcement by e-mail on April 2, 2010.

Godish, T. 1991. Air quality. 2nd ed. Michigan: Lewis Publishers, Inc. 422 pp.

Goh, B.P.L. and C.S. Lee. 2008. A study of the effect of sediment accumulation on the settlement of coral larvae using conditioned tiles. In: Proceedings of the 11th International Reef Symposium. July 7-11, 2008. Session No. 24. Fort Lauderdale, FL.

Gómez Gesteira, J.L. and J.C. Dauvin. 2000. Amphipods are good bioindicators of the impact of oil spills on soft-bottom macrobenthic communities. Marine Pollution Bulletin 40(11):1017-1027.

Gommes, R., J. du Guerny, F. Nachtergaele, and R. Brinkman. 1998. Potential impacts of sea level rise on populations and agriculture. Food and Agriculture Organization of the United Nations, Sustainable Development.

Gonzalez, A. 2010. U.S. gas boom orphans LNG. *The Wall Street Journal*. October 22, 2010. Internet website: http://online.wsj.com/article/SB10001424052702304023804575566570816389914.html. Accessed March 1, 2011.

Good, B., J. Buchtel, D. Meffert, J. Radford, K. Rhinehart, and R. Wilson. 1995. Louisiana's major coastal navigation channels. Louisiana Dept. of Natural Resources, Baton Rouge, LA. 35 pp. Internet website: http://dnr.louisiana.gov/crm/D%20R%20S%20Reports/General/La.%20Navigation%20Channels/Channels_1.pdf.

Gordon, J.C.D., D. Gillespie, L.E. Rendell, and R. Leaper. 1996. Draft report on playback of ATOC like sounds to sperm whales (*Pheseter macrocephalus*) off the Azores. Wildlife Conservation Research Unit, Dept. of Zoology, Oxford, UK.

Gore, R.H. 1992. The Gulf of Mexico. Pineapple Press, Florida.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas. 3 vols. U.S. Dept. of the Interior, Fish and Wildlife Services. FWS/OBS-78/9 through 78/11.

Gower, J. and S. King. 2008. Satellite images show the movement of floating Sargassum in the Gulf of Mexico and Atlantic Ocean. Nature Precedings: hdl:10101/npre.2008.1894.1.

Gower, J., C. Hu, G. Borstad, and S. King. 2006. Ocean color satellites show extensive lines of floating Sargassum in the Gulf of Mexico. IEEE Trans. Deosci. Rem. Sens. 44(12):3619-3625.

Graham, P. 1981. Status of white sturgeon in the Kootenai River. Montana Dept. of Fish, Wildlife, and Parks, Kalispell, MT.

Gramling, R. 1984a. Housing in the coastal zone parishes. In: Gramling, R.B. and S. Brabant, eds. The role of outer continental shelf oil and gas activities in the growth and modification of Louisiana's coastal zone. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration and Louisiana Dept. of Natural Resources, Lafayette, LA. Interagency Agreement NA-83-AA-D-CZ025; 21920-84-02. Pp. 127-134.

Gramling, R. 1984b. Offshore oil and gas activity and its socioeconomic and environmental influences. United States House of Representatives Subcommittee on Panama Canal/Outer Continental Shelf. Serial No. 98 37, P.302, Washington, DC: U.S. Government Printing Office.

Green, M.M., 2006. Coastal restoration annual project reviews, December 2006. Louisiana Dept. of Natural Resources, Baton Rouge, LA. 116 pp. Internet website: http://lacoast.gov/reports/apr/2006%20Coastal%20Restoration%20Annual%20Project%20Reviews.pdf.

Greenberg, J. 2010. Offshore outlook: Still no deepwater drilling permits. Internet website: http://www.workboat.com/blogpost.aspx?id=4295000422. Accessed December 14, 2010.

Greene, C.R. 1986. Underwater sounds from the semisubmersible drill rig SEDCO 708 drilling in the Aleutian Islands. Section 1. Washington, DC: American Petroleum Institute. API Publication 4438. 69 pp.

Greene, G., C. Moss, and T. Spreen. 1997. Demand for recreational fishing in Tampa Bay, Florida: A random utility approach. Marine Resource Economics 12:293-305.

Grigg, R.W. 1977. Population dynamics of two gorgonian corals. Ecology 58:278-290.

Grimm, D.E. and T.S. Hopkins. 1977. Preliminary characterization of the octocorallian and scleractinian diversity at the Florida Middle Ground. Proceedings, Third International Coral Reef Symposium, Miami, FL. 1:135-141.

Gulf Coast Claims Facility. 2010a. Program statistics & overall summary, and state status reports. Internet website: http://www.gulfcoastclaimsfacility.com/reports. Accessed November 27, 2010.

Gulf Coast Claims Facility. 2010b. Program frequently asked questions. Internet website: http://gulfcoastclaimsfacility.com/faq#Q11. Accessed November 2010.

Gulf of Mexico Alliance. 2009a. Gulf of Mexico Alliance water quality. Internet website: http://gulfofmexicoalliance.org/issues/welcome.html. Last updated June 2, 2009. Accessed March 15, 2010.

Gulf of Mexico Alliance. 2009b. Gulf of Mexico Alliance priority issues. Internet website: http://gulfofmexicoalliance.org/issues/welcome.html. Last updated June 2, 2009. Accessed March 15, 2010.

Gulf of Mexico Fishery Management Council (GMFMC). 2005. Generic amendment number 3 for addressing essential fish habitat requirements, habitat areas of particular concern, and adverse effects of fishing in the following fishery management plans of the Gulf of Mexico: shrimp fishery of the Gulf of Mexico, United States waters red drum fishery of the Gulf of Mexico, reef fish fishery of the Gulf of Mexico coastal migratory pelagic resources (mackerels) in the Gulf of Mexico and South Atlantic, stone crab fishery of the Gulf of Mexico, spiny lobster in the Gulf of Mexico and South Atlantic, coral and coral reefs of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL.

Gulf of Mexico Fishery Management Council (GMFMC). 2010a. Federal fishing rules for the Gulf of Mexico. Internet website: http://www.gulfcouncil.org/fishrules.htm. Accessed August 5, 2010.

Gulf of Mexico Fishery Management Council (GMFMC). 2010b. Supplemental recreational red snapper season to open October 1, 2010. Internet website: http://www.gulfcouncil.org/news_resources/Press%20Releases/2010RedSnapperReopening.pdf.

Gulf of Mexico Fishery Management Council (GMFMC). 2011. Recreational fishing regulations for Gulf of Mexico federal waters. Internet website: http://www.gulfcouncil.org/Beta/GMFMCWeb/downloads/rec_brochure_2010.pdf.

Gulf of Mexico Oil Spill Blog. 2010. Gulf Coast winners and losers. Internet website: http://gulfofmexicooilspillblog.com/2010/11/14/gulf-of-mexico-oil-spill-blog-gulf-coast-economic-winners-and-losers/. Posted November 14, 2010. Accessed December 15, 2010.

Guo, J., D.W. Hughes, and W.R. Keithly. 1998. An analysis of Louisiana Highway 1 in relation to expanding oil and gas activities in the Central Gulf of Mexico. In: Lafourche Parish and Port Fourchon, Louisiana: Effects of the Outer Continental Shelf Petroleum Industry on the Economy and Public Services, Part 1. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-019. 42 pp.

Guzmán, H.M. and I. Holst. 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea*. Marine Pollution Bulletin 26(5):276-282.

Guzmán, H.M., J.B.C. Jackson, and E. Weil. 1991. Short-term ecological consequences of a major oil spill on Panamanian subtidal reef corals. Coral Reefs 10:1-12.

Guzmán, H.M., K.A. Burns, and J.B.C. Jackson. 1994. Injury, regeneration, and growth of Caribbean reef corals after a major oil spill in Panama. Marine Ecology Progress Series 105:231-241.

Haab, T.C., J.C. Whitehead, and T. McConnell. 2000. The economic value of marine recreational fishing in the southeast United States: 1997 southeast economic data analysis; final report, July 2000. 105 pp. Internet website: http://www.st.nmfs.noaa.gov/st5/RecEcon/Publications/SE_vol2.pdf. Accessed April 4, 2011.

Haab, T.C., R. Hicks, K. Schnier, and J.C. Whitehead. 2010. Angler heterogeneity and the species-specific demand for marine recreational fishing. Appalachian State University, Department of Economics Working Paper. Number 10-02. 43 pp. Internet website: http://econ.appstate.edu/RePEc/pdf/wp1002.pdf.

Haag, W.G. 1992. The Monte Sano site. In: Jeter, M.D., ed. Southeastern Archaeological Conference: Abstracts of the Forty-ninth Annual Meeting, Arkansas' Excelsior Hotel, October 21-24, 1992. Little Rock, AR. 18 pp.

Haby, M.G., R.J. Miget, and L.L. Falconet. 2009. Hurricane damage sustained by the oyster industry and the oyster reefs across the Galveston Bay system with recovery recommendations. A Texas AgriLife Extension Service/SeaGrant Extension Program Staff Paper. The Texas A&M University System, College Station, TX. TAMU-SG-09-201. 51 pp.

Hagerty, C.L. and J.L. Ramseur, coordinators. 2010. *Deepwater Horizon* oil spill: Selected issues for Congress. Congressional Research Service. 49 pp. Internet website: http://www.fas.org/sgp/crs/misc/R41262.pdf.

Haig, S.H. and C.L. Ferland. 2002. 2001 international piping plover census. U.S. Dept. of the Interior, Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, OR. 293 pp.

Hale, L.F. and J.K. Carlson. 2007. Characterization of the shark bottom longline fishery, 2005-2006. NOAA Technical Memorandum NMFS-SEFSC-554. 28 pp.

Hale, L.F., L.D. Hollinsead, and J.K. Carlson. 2007. Characterization of the shark bottom longline fishery, 2007. NOAA Technical Memorandum NMFS-SEFSC-564. 25 pp.

Hale, L.F., S.J.B. Gulak, and J.K. Carlson. 2009. Characterization of the shark bottom longline fishery, 2008. NOAA Technical Memorandum NMFS-SEFSC-586. 23 pp.

Hall, E.R. 1981. The mammals of North America: Volume II. New York, NY: John Wiley and Sons. Pp. 667-670.

Hall, R.J., A.A. Belisle, and L. Sileo. 1983. Residues of petroleum hydrocarbons in tissues of sea turtles exposed to the *Ixtoc I* oil spill. Journal of Wildlife Diseases 19(2):106-109.

Halley, R.B., A.C. Hine, B.D. Jarrett, D.C. Twichell, D.F. Naar, G.D. Dennis, and K. Ciembronowicz. 2004. Pulley Ridge: The US's deepest hermatypic coral reef? A poster by the U.S. Dept. of the Interior, Geological Survey and University of South Florida, College of Marine Science, St. Petersburg, FL. Internet website: http://coastal.er.usgs.gov/pulley-ridge/Pulley_Ridge.pdf.

Hamilton, P. and A. Lugo-Fernandez. 2001. Observations of high speed deep currents in the northern Gulf of Mexico. Geophysical Research Letters 28:2767-2870.

Hamilton, P., J.J. Singer, E. Waddell, and K. Donuhue. 2003. Deepwater observations in the northern Gulf of Mexico from in-situ current meters and PIES: Final report. Volume II. Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS-2003-049. 95 pp.

Handley, D.A., D. Altsman, and R. DeMay, eds. 2007. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey Scientific Investigations Report

2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed May 13, 2011.

Haney, J.L, Y. Wei, and S.G. Douglas. 2004. A preliminary assessment of on-shore air quality impacts for the eastern Gulf Coast (Louisiana to Florida) using the 2000 Gulfwide Emissions Inventory: Draft report. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, by ICF Consulting, San Rafael, CA.

Hanski, I. 1999. Metapopulation ecology. Oxford: Oxford University Press. 328 pp.

Harbison, R.N. 1968. Geology of De Soto Canyon. Journal of Geophysical Research 73:5175-5185.

Hardin, D.K., K.D. Spring, S.T. Viada, A.D. Hart, B.D. Graham, and M.B. Peccini. 2001. Chapter 7: Hard bottom communities. In: Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group. 2001. Mississippi/Alabama pinnacle trend ecosystem monitoring: Final synthesis report. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS BSR 2001-0007 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2001-080. 415 pp. + apps.

Hargreaves, S. 2010. Drilling ban: Jobs at stake. Internet website: http://money.cnn.com/2010/06/24/news/economy/drilling_jobs_at_stake/index.htm?postversion=2010062410. Accessed June 30, 2010.

Harper, D.E., Jr. 1991. Macroinfauna and macroepifauna. In: Brooks, J.M., ed. 1991. Mississippi-Alabama continental shelf ecosystem study: Data summary and synthesis. Volume II: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0063. 862 pp.

Harper, D.E., Jr., L.D. McKinney, J.M. Nance, and R.R. Salzer. 1991. Recovery responses of two benthic assemblages following an acute hypoxic event on the Texas continental shelf, northwestern Gulf of Mexico. Geological Society, London, Special Publications 58:49-64.

Harris, J.E. 2003. Distribution of Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*) in relation to environmental parameters and the distribution of benthic invertebrates in the Suwannee River Estuary, Florida. Master's Thesis. The University of Florida, Gainesville, FL.

Harris, R. 2010. Scientists find thick layer of oil on seafloor. National Public Radio (online). September 10, 2010. Internet website: http://www.npr.org/templates/story/story.php?storyId=129782098. Accessed January 13, 2011.

Harris, J.E., D.C. Parkyn, and D.J. Murie. 2005. Distribution of Gulf of Mexico sturgeon in relation to benthic invertebrate prey resources and environmental parameters in the Suwannee River estuary, Florida. Transactions of the American Fisheries Society 134:975-990.

Harrison, P. 1983. Seabirds: An identification guide. Boston, MA: Houghton Mifflin Co. 448 pp.

Harrison, P. 1996. Seabirds of the world. Princeton, NJ: Princeton University Press. 317 pp.

Hart, A.D., K.D. Spring, J.M. Brooks, B.J. Presley, and B.A. Vittor. 1989. Fate and effects of drilling fluid and cutting discharges in shallow, nearshore waters. Washington, DC: American Petroleum Institute.

Hartung, R. 1995. Assessment of the potential for long-term toxicological effects of the *Exxon Valdez* oil spill on birds and mammals. ASTM (American Society for Testing Materials) Special Technical Publication.

Harvey, J.T. and M.E. Dahlheim. 1994. Cetaceans in oil. In: Loughlin, T.R., ed. Marine Mammals and the *Exxon Valdez*. San Diego, CA: Academic Press. Pp. 257-264.

Hayes, M.O., D.D. Domeracki, C.D. Getter, T.W. Kana, and G.I. Scott. 1980. Sensitivity of coastal environments to spilled oil, south Texas coast. Research Planning Institute, Inc. Report No. RPI/R/80/4/11-12. Prepared for the U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, Columbia, SC. 89 pp.

Hayman, P., J. Marchant, and T. Prater. 1986. Shorebirds: An identification guide to the waders of the world. Boston, MA: Houghton Mifflin Co. 412 pp.

Hazen, T.C., E.A. Dubinsky, T.Z. DeSantis, G.L. Andersen, Y.M. Picento, N. Singh, J.K. Jansson, A. Probst, S.E. Borglin, J.L. Fortney, W.T. Stringfellow, M. Bill, M.S. Conrad, L.M. Tom, K.L. Chavarria, T.R. Alusi, R. Lamendella, D.C. Joyner, C. Spier, J. Baelum, M. Auer, M.L. Zelma, R. Chakraborty, E.L. Sonnenthal, P. D'haeseleer, H.N. Holman, S. Osman, Z. Lu, J.D. Van Nostrand, Y. Deng, J. Zhou, and O.U. Mason. 2010. Deep-sea oil plume enriches indigenous oil-degrading bacteria. Published online: Science Express August 24, 2010. Science 330:6001(204-208).

Heard, R.W., J.A. McLelland, and J.M. Foster. 2002. Direct and indirect observations of the diet, seasonal occurrence, and distribution of the Gulf sturgeon, *Acipenser oxyrinchus desotoi* Valdykov, 1955, from the Choctawhatchee Bay System, Florida, in relation to macroinvertebrate assemblages and parasites. Final report to the Florida Fish and Wildlife Service. 34 pp.

Heath, A.G. 1995. Water pollution and fish physiology. 2nd edition. Boca Raton, FL: CRC Press, Inc. 359 pp.

Heck, K.L., G. Hays, and R.J. Orth. 2003. Critical evaluation of the nursery role hypothesis for seagrass meadows. Marine Ecology Progress Series 253:123-136.

Helicopter Safety Advisory Conference. 2009. HSCA 2009 safety statistics. Internet website: http://www.hsac.org/Minutes/may2010/2009SAFETYSTAT.pdf. Accessed December 17, 2010.

Hell, J.W. and M.D. Ehlers, eds. 2008. Structural and functional organization of the synapse. New York, NY: Springer. 801 pp.

Hemmerling, S.A. and C.E. Colten. 2003. Environmental justice considerations in Lafourche Parish, Louisiana. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-038. 348 pp.

Hemmerling, S.A. and C.E. Colten. In preparation. Environmental justice: A comparative perspective in Louisiana. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. Prepared under Contract No. 30951-72404.

Hemming, J.M. , P.V. Winger, S.J. Herrington, W. Gierhart, H. Herod, and J. Ziewitz. 2006. Water and sediment quality integrity survey of threatened and endangered freshwater mussel habitat in the Ochlockonee River basin. Endangered Species Research 6:1-13.

Heneman, B. and the Center for Environmental Education. 1988. Persistent marine debris in the North Sea, northwest Atlantic Ocean, wider Caribbean area, and the west coast of Baja California. Final report for the Marine Mammal Commission. Contract MM3309598-5. Washington, DC. Available from NTIS, Springfield, VA: PB89-109938. 161 pp.

Henfer, L.M., B.O. Wilen, T.E. Dahl, and W.E. Frayer. 1994. Southeast wetlands: Status and trends, mid-1970's to mid-1980's. U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 32 pp.

Henningsson, S.S. and T. Alerstam. 2005. Barriers and distances as determinants for the evolution of bird migration links: The Arctic shorebird system. In: Proceedings; Biological Sciences, 2005. London: Royal Society of London 272(1578):2251-2258.

Henriet, J.P. and J. Mienert. 1998. Gas hydrates; relevance to world marginal stability and climate change. Geological Society of London, England. Geological Society Special Publication No. 137. 338 pp.

Henry, J. and C.L. Bankston III. 1999. Louisiana Cajun ethnicity: Symbolic or structural? Sociological Spectrum 19(2):223-248.

Hernandez, F., S. Powers, and W. Graham. 2010. Seasonal variability in ichthyoplankton abundance and assemblage composition in the northern Gulf of Mexico off Alabama. Fishery Bulletin 108(2):193-207.

Hickerson, E.L., G.P. Schmahl, M. Robbart, W.F. Precht, and C. Caldow. 2008. The state of coral reef ecosystems of the Flower Garden Banks, Stetson Bank, and other banks in the northwestern Gulf of Mexico. In: Waddell, J.E. and A.M. Clarke, eds. The state of coral reef ecosystems of the United States and Pacific freely associated states: 2008. Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS. 569 pp.

Hiett, R.L. and J.W. Milon. 2002. Economic impact of recreational fishing and diving associated with offshore oil and gas structures in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-010. 98 pp.

Hobaugh, W.C., C.D. Stutzenbaker, and E.L. Flickinger. 1989. The rice prairies. In: Smith, L.M., R.L. Pederson, and R.M. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

Hogan, J.L. 2003. Occurrence of the diamondback terrapin (*Malaclemys terrapin littoralis*) at South Deer Island in Galveston Bay, Texas, April 2001–May 2002. U.S. Dept. of the Interior, Geological Survey, Austin, TX. USGS Open-File Report 03-022. 30 pp.

Holand, P. 1999. Reliability of subsea BOP systems for deepwater application, phase II DW. SINTEF Report prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 319. 118 pp. + apps. Internet website: http://www.boemre.gov/tarprojects/319/319AA.pdf.

Holand, P. and P. Skalle. 2001. Deepwater kicks and BOP performance. SINTEF Report prepared for U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 383. 108 pp. + apps. Internet website: http://www.boemre.gov/tarprojects/383/383%20AB%20Final%20report%20Deepwater%20Kicks%20and%20BOP%20Performance.pdf.

Holder, Jr., S.W. and A. Lugo-Fernandez. 1993. Relationships between the Barataria Basin tidal prism and the basin's barrier islands. In: Clipp, A., ed. Louisiana shoreline erosion: Emphasis on Grand Isle. Proceedings of a symposium held at Grand Isle, LA, March 3-5, 1993. Pp. 31-42.

Holdway, D.A. 2002. The acute and chronic effects of wastes associated with offshore oil and gas production on temperate and tropical marine ecological processes. Marine Pollution Bulletin 44:185-203.

Holliman, D.C. 1983. Status and habitat of Alabama Gulf Coast beach mice *Peromyscus polionotus ammobates* and *P.p. trissyllepsis*. Northeast Gulf Science 6(2):121-129.

Hopkins, T.S., D.R. Blizzard, S.A. Brawley, S.A. Earle, D.E. Grimm, D.K. Gilbert, P.G. Johnson, E.H. Livingston, C.H. Lutz, J.K. Shaw, and B.B. Shaw. 1977. A preliminary characterization of the biotic components of composite strip transects on the Florida Middle Ground, northeastern Gulf of Mexico. Proceedings, Third International Coral Reef Symposium, Miami, FL. 1:32-37.

Howard, R.K. and F.T. Short. 1986. Seagrass growth and survivorship under the influence of epiphyte grazers. Aquatic Botany 24(3):287-302.

Hsu, S.A. 1979. An operational forecasting model for the variation of mean maximum mixing heights across the coastal zone. Boundary-Layer Meteorology 16:93-98.

Hu, C. and F.E. Muller-Karger. 2007. Response of sea surface properties to Hurricane Dennis in the eastern Gulf of Mexico. Geophysical Research Letters Vol. 34, L07606, doi:10.1029/2006GL028935.

Hua, J. 1999. Behavior of chemically dispersed oil in marine sediment. Journal of Marine Science and Technology 7(1):35-42.

Hudson, J.H. and D.M. Robbin. 1980. Effects of drilling mud on the growth rate of reef-building coral, *Montastraea annularis*. The R&D Program for OCS Oil and Gas Operations. U.S. Dept. of the Interior, Geological Survey, Fisher Island Station, Miami Beach, FL.

Hudson, J.H., E.A. Shinn, and D.M. Robbin. 1982. Effects of offshore oil drilling on Philippine reef corals. Bulletin of Marine Science 32(4):890-908.

Huff, J.A. 1975. Life history of the Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*, in the Suwannee River, Florida. Marine Resources Publication No. 16. 32 pp.

Hughes, D.W., J.M. Fannin, W. Keithly, W. Olatubi, and J. Guo. 2001. Lafourche Parish and Port Fourchon, Louisiana: Effects of the outer continental shelf petroleum industry on the economy and public services, part 2. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-020. 51 pp.

Hummell, R.L. 1990. Main Pass and the ebb-tidal delta of Mobile Bay, Alabama. Geological Survey of Alabama, Energy and Coastal Geology Division. Circular 146.

Hunt D. 2006. Personal communication. Impacts of Hurricanes Rita and Katrina on bird habitat. U.S. Dept. of the Interior, Fish and Wildlife Service, Southeastern Louisiana Wildlife Refuges, Lacombe, LA. September 2006.

Hyland, J.L. and E.D. Schneider. 1976. Petroleum hydrocarbons and their effects on marine organisms, populations, communities, and ecosystems. In: Sources, effects and sinks of hydrocarbons in the aquatic environment. Proceedings of the Symposium, Washington, DC. August 9-11, 1976. Arlington, VA: American Institute of Biological Sciences. Pp. 465-506.

Hyland, J., D. Hardin, M. Steinhauer, D. Coats, R. Green, and J. Neff. 1994. Environmental impact of offshore oil development on the outer continental shelf and slope off Point Arguello, California. Marine Environmental Research 37:195-229.

IEM. 2010. A study of the economic impact of the *Deepwater Horizon* oil spill. Part 1: Fisheries. Prepared for the Greater New Orleans Inc. Regional Economic Alliance. 55 pp. Internet website: http://www.uflib.ufl.edu/docs/Economic%20Impact%20Study,%20Part%20I%20-%20Full%20Report.pdf.

Iledare, O.O. and M.J. Kaiser. 2007. Competition and performance in oil and gas lease sales and development in the U.S. Gulf of Mexico OCS region, 1983-1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-034. 106 pp.

Inoue, M., S.E. Welsh, L.J. Rouse, Jr., and E. Weeks. 2008. Deepwater currents in the eastern Gulf of Mexico: Observations at 25.5ºN and 87ºW. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-001. 95 pp.

Intergovernmental Panel on Climate Change. 2007a. Summary for policymakers. In: Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY. 24 pp. Internet website: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

Intergovernmental Panel on Climate Change. 2007b. IPCC fourth assessment report. Internet website: http://www.ipcc.ch/ipccreports/ar4-wg1.htm. Accessed February 8, 2011.

International Tanker Owners Pollution Federation Limited (ITOPF). 2007. Fate of marine oil spills. Technical Information Paper. London, United Kingdom. 8 pp. Internet website: http://www.itopf.com/_assets/documents/tip2.pdf. Accessed December 2, 2010.

International Tanker Owners Pollution Federation Limited (ITOPF). 2010a. Weathering process. Internet website: http://www.itopf.com/marine-spills/fate/weathering-process/. Accessed January 4, 2011.

International Tanker Owners Pollution Federation Limited (ITOPF). 2010b. Containment & recovery. Internet website: http://www.itopf.com/spill-response/clean-up-and-response/containment-and-recovery/. Accessed December 23, 2010.

Irion, J.B. and R.J. Anuskiewicz. 1999. MMS seafloor monitoring project: First annual technical report, 1997 field season. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. OCS Report MMS 99-0014. 63 pp.

Irion, J.B. and D.A. Ball. 2001. The *New York* and the *Josephine*: Two steamships of the Charles Morgan Line. International Journal of Nautical Archaeology 30(1):48-56.

Irvine, G. 2000. Persistence of spilled oil on shores and its effects on biota. In: Seas at the millennium: An environmental evaluation. Volume III: Global issues and processes. Elsevier Science Ltd.

Isphording, W.C. and G.C. Flowers. 1990. Geological and geochemical characterization. In: Stout, J., and L. Bryant, eds. Mobile Bay: Issues, resources, status, and management. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. Estuary-of-the-Month Seminar Series No. 15. Pp. 9-25.

Israel, B. 2010. 5 years after Katrina, Gulf ecosystems on the ropes. Live Science. Internet website: http://www.livescience.com/environment/hurricane-katrina-gulf-coast-ecological-damage-100827.html. Accessed August 27, 2010.

Izon, D., E.P. Danenberger, and M. Mayes. 2007. Absence of fatalities in blowouts encouraging in MMS study of OCS incidents 1992-2006. Drilling Contractor, July/August. Pp. 84-90. Internet website: http://drillingcontractor.org/dcpi/dc-julyaug07/DC_July07_MMSBlowouts.pdf.

Jaap, W.C. and R. Halley. 2008. Pulley Ridge. In: Ritchie, K.B. and B.D. Keller, eds. A scientific forum on the Gulf of Mexico: The islands in the stream concept. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. Marine Sanctuaries Conservation Series NMSP-08-04. Pp. 45-48. Internet website: http://sanctuaries.noaa.gov/science/conservation/pdfs/gom.pdf.

Jaap, W.C. and P. Hallock. 1991. Coral reefs. In: Myers, R.L. and J.J. Ewel, eds. Ecosystems of Florida. Orlando, FL: University of Central Florida Press. Pp. 574-616.

Jackson, J.B.C., J.D. Cubit, B.D. Keller, V. Batista, K. Burns, H.M. Caffey, R.L. Caldwell, S.D. Garrity, C.D. Getter, C. Gonzalez, H.M. Guzman, K.W. Kaufmann, A.H. Knap, S.C. Levings, M.J. Marshall, R. Steger, R.C. Thompson, and E. Weil. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243:37-44.

Jackson, L.E., J.C. Kurtz, and W.S. Fisher. 2000. Evaluation guidelines for ecological indicators. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA/620/R-99/005. Internet website: http://www.epa.gov/emap/html/pubs/docs/resdocs/ecol_ind.pdf.

Jarrett, B.D., A.C. Hine, A.C. Neumann, D. Naar, S. Locker, D. Mallinson, and W. Jaap. 2002. Deep biostromes at Pulley Ridge, southwest Florida carbonate platform. University of South Florida, St. Petersburg, FL. Internet website: http://rubicon-foundation.org/dspace/bitstream/123456789/8968/1/AAUS_2000_8.pdf.

Jefferson, T.A., S. Leatherwood, L.K.M. Shoda, and R.L. Pitman. 1992. Marine mammals of the Gulf of Mexico: A field guide for aerial and shipboard observers. Texas A&M University Printing Center, College Station, TX. 92 pp.

Jenssen, B.M. 1994. Review article: Effects of oil pollution, chemically treated oil, and cleaning on the thermal balance of birds. Environmental Pollution 86:207-215.

Jenssen, B.M. and M. Ekker. 1991. Effects of plumage contamination with crude oil disperant mixtures on thermoregulation in common eiders and mallards. Archives of Environmental Contamination and Toxicology 20:398-403.

Jernelöv, A. and O. Lindén. 1981. *Ixtoc I*: A case study of the world's largest oil spill. Ambio 10(6):299-306.

Ji, Z.-G., W.R. Johnson, C.F. Marshall, and E.M. Lear. 2007. Oil spill risk analysis: Gulf of Mexico outer continental shelf (OCS) lease sales, Central Planning Area and Western Planning Area, 2007-

2012, and Gulfwide OCS Program, 2007-2046. U.S. Dept. of the Interior, Minerals Management Service, Environmental Division, Herndon, VA. OCS Report MMS 2007-040. 59 pp.

Jindal, B. 2010. Governor Jindal letter to President Obama and Secretary Salazar: Severe impacts of moratorium on deepwater drilling. Press Release, June 3, 2010. Internet website: http://emergency.louisiana.gov/Releases/06032010-letter.html. Accessed January 13, 2011.

Jochens, A.E., L.C. Bender, S.F. Di Marco, J.W. Morse, M.C. Kennicutt II, M.K. Howard, and W.D. Nowlin, Jr. 2005. Understanding the processes that maintain the oxygen levels in the deep Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-032. 129 pp.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

Johansen, O., H. Rye, and C. Cooper. 2001. DeepSpill JIP—field study of simulated oil and gas blowouts in deep water. In: Proceedings from the Fifth International Marine Environment Modeling Seminar, October 9-11, 2001, New Orleans, LA. 377 pp.

Johnsgard, P.A. 1975. Waterfowl of North America. Bloomington, IN: Indiana University Press. 624 pp.

Johnson, W.B. and J.G. Gosselink. 1982. Wetland loss directly associated with canal dredging in the Louisiana coastal zone. In: Boesch, D.F., ed. Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options, Baton Rouge, LA. U.S. Dept. of the Interior, Fish and Wildlife Service. FWS/OBS-82/59. Pp. 60-72.

Johnson, G.C., R.E. Kidd, C.A. Journey, H. Zappia, and J.B. Atkins. 2002. Environmental setting and water-quality issues of the Mobile River Basin, Alabama, Georgia, Mississippi, and Tennessee. U.S. Dept. of the Interior, Geological Survey Water-Resources Investigations Report 02-4162. 61 pp.

Johnston, J.B., D.R. Cahoon, and M.K. La Peyre. 2009. Outer continental shelf (OCS)-related pipelines and navigation canals in the Western and Central Gulf of Mexico: Relative impacts on wetland habitats and effectiveness of mitigation. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-048. 200 pp.

Joint Analysis Group. 2010a. Review of R/V *Brooks McCall* data to examine subsurface oil. Internet website: http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf. Accessed October 14, 2010.

Joint Analysis Group. 2010b. Review of preliminary data to examine oxygen levels in the vicinity of MC525#1. May 8 to August 9, 2010. Internet website: http://www.noaa.gov/sciencemissions/PDFs/JAG_Oxygen_Report%20(FINAL%20090410).pdf. Accessed October 19, 2010.

Jones, P. and G. Wells. 1987. Shuttle views the Earth: Oceans from space. Space shuttle views and explanation. LPI slide set contribution no. 1181. Slide nos. 30 and 31. Shuttle views from 1987. The Lunar and Planetary Institute, NASA. Contract # NASW-4574 operated by the Universities Space Research Association. Internet website: http://www.lpi.usra.edu/publications/slidesets/oceans/index.shtml. Accessed December 2011.

Joye, S. 2010. Focusing in on oil, scientist' log from September 5, 2010, aboard the R/V *Oceanus* in the northern Gulf of Mexico. Gulf Oil Blog, University of Georgia, Dept. of Marine Sciences. Internet website: http://gulfblog.uga.edu/2010/09/focusing-in-on-oil. Accessed September 15, 2010.

Kaplan, M.F. and C. Whitman. Unpublished. Measuring the economic impact of tourism and recreation industries on Gulf Coast communities—Relationship between OCS development and coastal resources (2008). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Contract No. 1435-01-99-CA-30951-18261. x + 164 pp.

Kaplan, M.F., A. Laughland, and J. Mott. In preparation. Infrastructure fact book. Volume II: OCS-related infrastructure and communities in the Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA.

Karl, T.R., J.M. Melillo, and T.C. Peterson, eds. 2009. Global climate change impacts in the United States. New York, NY: Cambridge University Press. 180 pp. Internet website: http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

Keim, B. and R.A. Muller. 2009. Hurricanes of the Gulf of Mexico. Louisiana State University Press, Baton Rouge, LA.

Kemp, G.P. 1986. Mud deposition at the shoreface: Wave and sediment dynamics on the Chenier Plain of Louisiana. Ph.D. dissertation. Louisiana State University, Baton Rouge, LA. 148 pp.

Kemp, W.M. 1989. Estuarine seagrasses. In: Day, J.W., Jr., C.A.S. Hall, W.M. Kemp, and A. Yanez-Arancibia, eds. Estuarine ecology. New York, NY: John Wiley & Sons. 558 pp.

Kendall, J.J. and G. Rainey. 1991. Produced waters: Findings of recent studies in the coastal waters of Louisiana; session introduction. In: Geo-Marine, Inc., comp. Proceedings: Eleventh Annual Gulf of Mexico Information Transfer Meeting, November 1990. U.S. Dept. of the Interior, Minerals Management Service, Gul of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0040. 524 pp.

Kennedy, C.J., N.J. Gassman, and P.J. Walsh. 1992. The fate of benzo[a]pyrene in the Scleractinian corals *Favia fragrum* and *Montastrea annularis*. Marine Biology 113:313-318.

Kennet, J.P. 1982. Marine geology. Englewood Cliff, NJ: Prentice-Hall. 752 pp.

Kennicutt II, M.C., ed. 1995. Gulf of Mexico offshore operations monitoring experiment, Phase I: Sublethal responses to contaminant exposure, final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0045. 709 pp.

Kennicutt II, M.C., J.M. Brooks, R.R. Bidigare, R.A. Fay, T.L. Wade and T.J. McDonald. 1985. Vent type taxa in a hydrocarbon seep region on the Louisiana slope. Nature (London) 317:351-353.

Kennicutt II, M.C., J. Sericano, T. Wade, F. Alcazar, and J.M. Brooks. 1987. High-molecular weight hydrocarbons in the Gulf of Mexico continental slope sediment. Deep-Sea Research 34:403-424.

Kennicutt II, M.C., P.N. Boothe, T.L. Wade, S.T. Sweet, R. Rezak, F.J. Kelly, J.M. Brooks, B.J. Presley, and D.A. Wiesenburg. 1996. Geochemical patterns in sediments near offshore production platforms. Canadian Journal of Fisheries and Aquatic Science 53: 2554-2566.

Kenworthy, W.J. and M.S. Fonseca. 1996. Light requirements of seagrasses *Halodule wrightii* and *Syringodium filiforme* derived from the relationship between diffuse light attenuation and maximum depth distribution. Estuaries 19(3):740-750.

Kenworthy, W.J., M.J. Durako, S.M.R. Fatemy, H. Valavis, and G.W. Thayer. 1993. Ecology of seagrasses in northeastern Saudi Arabia one year after the Gulf War spill. Marine Pollution Bulletin 27:213-222.

Kessler, J.D., D.L Valentine, M.C. Redmond, M. Du., E.W. Chan, S.D. Mendes, E.W. Quiroz, C.J. Villanueva, S.S. Shusta, L.M. Werra, S.A. Yvon-Lewis, and T.C. Weber. 2011. A persistent oxygen anomaly reveals the fat of spilled methane in the deep Gulf of Mexico. Science Express. Internet website: http://www.sciencemag.org/content/early/2011/01/05/science.1199697. Posted January 6, 2011. Accessed May 20, 2011.

Khan, R.A. and P. Ryan. 1991. Long-term effects of crude oil on common murres (*Uria aalge*) following rehabilitation. Bulletin of Environmental Contamination and Toxicology 46:216-218.

Khodorevskaya, R.P., O.L. Zhravleva, and A.D. Vlasenko. 1997. Present status of commercial stocks of sturgeons in the Caspian Sea basin. Environ. Biol. Fish. 48:209-219.

Kilpatrick, A.M., S.L. LaDeau, and P.P. Marra. 2007. Ecology of West Nile virus transmission and its impact on birds in the Western Hemisphere. Auk 124:1121-1136.

King, W.E. 2007. Energy alternatives and the environment. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS Report MMS 2007-016. 46 pp.

Kingston, P.F. 1995. The *Exxon Valdez* and *Braer* oil spills; a comparison of their impacts on the marine environment. Deutsche Hydrographische Zeitschrift Supplement 5:59-72.

Kingston, P.F., I.M.T. Dixon, S. Hamilton, and D.C. Moore. 1995. The impact of the *Braer* oil spill on the macrobenthic infauna of the sediments off the Shetland Isles. Marine Pollution Bulletin 189:159-170.

Kirk, J.P. 2007. Personal communication. Information describing the latest unpublished sturgeon population estimates for Gulf sturgeon in the Pearl River. U.S. Dept. of the Army, Corps of Engineers, Engineering Research and Development Center. January 2007.

Kirk, J.P. 2008. Gulf sturgeon movements in and near the Mississippi River Gulf Outlet. U.S. Dept. of the Army, Corps of Engineers, Engineering Research Development Center, Environmental Lab. ERDC/EL TR-08-18.

Kirk, P. 2010. Personal communication. Status of potential new habitat in the Brothers River. U.S. Dept. of the Army, Corps of Engineers. December 2010.

Kirk, J.P. and H.R. Rogillio. 2007. Personal communication. Information describing the latest unpublished sturgeon population estimates for Gulf sturgeon in the Pearl River. J.P. Kirk, U.S. Dept. of the Army, Corps of Engineers, Research and Development Center, Vicksburg, MS; and H.R. Rogillio, Louisiana Dept. of Wildlife and Fisheries, Lacombe, LA.

Kita, J. and T. Ohsumi. 2004. Perspectives on biological research for CO_2 ocean sequestration. Journal of Oceanography 60(4):695-703.

Klasing, K., R. Donohoe, and J. Yamamoto. 2007. Dietary exposure to naphthalene in the Japanese quail (*Coturnix coturnix japonica*). In: Massey, J.G., ed. Proceedings of the Ninth International Effects of Oil on Wildlife Conference, Monterey, California, 2007, University of California at Davis Wildlife Health Center.

Klein, M.L., S.R. Humphrey, and H.F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9:1454-1465.

Kleinosky, L., B. Yarnal, and A. Fisher. 2007. Vulnerability of Hampton Roads, Virginia to storm-surge flooding and sea-level rise. Natural Hazards 40(1):43-70.

Kleypas, J.A., J.W. McManus, and L.A.B. Meñtz. 1999a. Environmental limits to coral reef development: Where do we draw the line? American Zoologist 39:146-159.

Kleypas, J.A., R.W. Buddemeier, D. Archer, J. Gattuso, C. Langdon, and B.N. Opdyke. 1999b. Geochemical consequences of increased atmospheric carbon dioxide on coral reefs. Science 284(5411):118-120.

Knap, A.H. 1987. Effects of chemically dispersed oil on the brain coral, *Diploria strigosa*. Marine Pollution Bulletin 18(3):119-122.

Knap, A.H., J.E. Solbakken, R.E. Dodge, T.D. Sleeter, S.J. Wyers, and K.H. Palmork. 1982. Accumulation and elimination of (9-^{14}C) phenanthrene in the reef-building coral (*Diploria strigosa*). Bulletin of Environmental Contamination and Toxicology 28:281-284.

Knap, A.H., T.D. Sleeter, R.E. Dodge, S.C. Wyers, H.R. Frith, and S.R. Smith. 1983. The effects of oil spills and dispersant use on corals: A review and multidisciplinary experimental approach. Oil and Petrochemical Pollution 1(3):157-169.

Knutson, T.R. and R.E. Tuleya. 2004. Impact of CO_2—induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization. Journal of Climate 17(18):3477–3495.

Ko, J-Y. and J.W. Day. 2004a. A review of ecological impacts of oil and gas development on coastal ecosystems in the Mississippi delta. Ocean and Coastal Management 47(11-12):597-623.

Ko, J-Y. and J.W. Day. 2004b. Wetlands: Impacts of energy development in the Mississippi Delta. Encyclopedia of Energy, Volume 6. Elsevier Inc. Pp. 397-408. Internet website: http://www.lsu.edu/cei/research_projects/Wetlands_final.pdf.

Kont, A., J. Jaagus, and R. Aunap. 2003. Climate change scenarios and the effect of sea-level rise for Estonia. Global and Planetary Change 36:1-15.

Korschgen, C.E., L.S. George, and W.L. Green. 1985. Disturbance of diving ducks by boaters on a migrational staging area. Wildlife Society Bulletin 13:290-296.

Kou, W.W. 2010. Direct seismic indicators of gas hydrates in the Walker Ridge and Green Canyon Areas, deepwater Gulf of Mexico. American Association of Petroleum Geologists, Search and Discovery Article #80112. Internet website: http://www.searchanddiscovery.com/documents/2010/80112kou/ndx_kou.pdf. Posted October 22, 2010.

Krapu, G.L., J.L. Eldridge, C.L. Gratto-Trevor, and D.A. Buhl. 2006. Fat dynamics of Arctic-nesting sandpipers during spring in mid-continental North America. Auk 123:323-334.

Kraus, R.T., R.L. Hill, J.R. Rooker, and T.M. Dellapenna. 2006. Preliminary characterization of a mid-shelf bank in the northwestern Gulf of Mexico as essential habitat of reef fishes. In: Proceedings of the 57th Gulf and Caribbean Fisheries Institute, November 8-12, 2004, St. Petersburg, FL. Pp. 621-632.

Kraus, R.T., C. Friess, R.L. Hill, and J.R. Rooker. 2007. Characteristics of the snapper-grouper-grunt complex, benthic habitat description, and patterns of reef fish recruitment at Sonnier Bank in the northwestern Gulf of Mexico. In: Proceedings of the 59th Gulf and Caribbean Fisheries Institute, November 6-11, 2006, Belize City, Belize. Pp. 165-170.

Kreiser, B.R., F. Parauka, J. Berg, M. Randall, K. Sulak, S. Floyd, and B. Young. 2008. Documentation of a Gulf sturgeon spawning site on the Yellow River, Alabama. Gulf and Caribbean Research 20:91-95.

Krivor, M.C., J. de Bry, N.J. Linville, and D.J. Wells. In press. Archival investigations for potential colonial-era shipwrecks in ultra-deep water in the Gulf of Mexico. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-004. 158 pp.

Kruse, G.O. and D.L. Scarnecchia. 2002. Assessment of bioaccumulated metal and organochlorine compounds in relation to physiological biomarkers in Kootenai River white sturgeon. J. App. Ichthyol. 18:430-438.

Kuhn, N.L., I.A. Mendelssohn, and D.J. Reed. 1999. Altered hydrology effects on Louisiana salt marsh function. Wetlands 19:3.

Kushmaro, A., G. Henning, D.K. Hofmann, and Y. Benayahu. 1997. Metamorphosis of *Heteroxenia fuscescens* Plaunlae (Cnidaria: Octocorallia) is inhibited by crude oil: A novel short term toxicity bioassay. Marine Environmental Research 43(4):295-302.

LA 1 Coalition. 2010a. LA 1 Coalition continues aggressive efforts to fund phase 2 of highway project in the wake of Tiger 2 grant results. Press Release. Internet website: http://la1coalition.org/images/Oct21_10LA1NewsRelease.pdf. Accessed December 3, 2010.

LA 1 Coalition. 2010b. One to One. Fall 2010 Newsletter. Internet website: http://www.la1coalition.org/images/Fall2010webLA1news.pdf.

LaCoast.gov. 2010a. CWPPRA projects. Internet website. http://www.lacoast.gov/projects/list.asp. Accessed January 13, 2011.

LaCoast.gov. 2010b. Coastal Wetlands Planning, Protection, and Restoration Act: Summary of wetland benefit for priority list projects. Internet website: http://www.lacoast.gov/reports/wva/CWPPRA%20project%20benefits%202010-03-22.pdf. Posted March 22, 2010. Accessed May 24, 2010.

LaCoast.gov. 2010c. The Calcasieu/Sabine Basin. Internet website: http://lacoast.gov/new/About/Basin_data/cs/Default.aspx. Accessed September 29, 2010.

LaCoast.gov. 2011. Atchafalaya Basin: Summary of basin plan. Internet website: http://lacoast.gov/new/About/Basin_data/at/Default.aspx. Accessed January 28, 2011.

Lack, D.L. 1968. Ecological adaptations for breeding in birds. London: Methuen. 409 pp.

LaDeau, S.L., A.M. Kilpatrick, and P.P. Marra. 2007. West Nile virus emergence and large-scale declines of North American bird populations. Nature 447:710-714 and Supplementary Information, 10 pp.

Lambert, G., D.B. Peakall, B.J.R. Philogene, and F.R. Engelhardt. 1982. Effect of oil and oil dispersant mixtures on the basal metabolic rate of ducks. Bulletin of Environmental Contamination and Toxicology 29:520-524.

Landsea, C.W., B.A. Harper, K. Hoarau, and J.A. Knaff. 2006. Can we detect trends in extreme tropical cyclones? Science 313:452-454.

Lange, R. 1985. A 100-ton experimental oil spill at Halten Bank, off Norway. In: Proceedings, 1985 Oil Spill Conference, February 25-28, 1985, Los Angeles, CA. Washington, DC: American Petroleum Institute.

Lange, J.L., D.A. Schwartz, B.N. Doebbeling, J.M. Heller, and P.S. Thorne. 2002. Exposures to the Kuwait oil fires and their association with asthma and bronchitis among gulf war veterans. Environmental Health Perspectives 110(11):1141-1146.

Leahy, J.G. and R.R. Colwell. 1990. Microbial degradation of hydrocarbons in the environment. Microbiological Reviews 54(3):305-315.

LeBlanc, D.J. 1985. Environmental and construction techniques involved with the installation of a gas pipeline across Timbalier Island, Louisiana. In: Proceedings, Sixth Annual Gulf of Mexico Information Transfer Meeting, October 22-24, 1985. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 86-0073. Pp. 203-205.

Leblanc, D. 2010. Personal communication. Lack of ecological change in the beach mouse after the *Deepwater Horizon* event. Wildlife Biologist, U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services Office, Daphne, AL. July 6, 2010.

Lee, M.R. and T.C. Blanchard. 2010. Health impacts of *Deepwater Horizon* oil disaster on coastal Louisiana residents. Louisiana State University, Department of Sociology, Baton Rouge, LA.

Lee, D.S. and M.L. Moser. 1998. Importance des Sargasses pelagiques pour la recherché alimentaire des oiseaux marins. El Pitirre 11(3):111-112.

Leighton, F.A. 1993. The toxicity of petroleum oils to birds. Environmental Reviews 1:92-103.

Lewis, J.B. 1971. Effect of crude oil and an oil-spill dispersant on reef corals. Marine Pollution Bulletin 2:59-62.

Lewis, A. and D. Aurand. 1997. Putting dispersants to work: Overcoming obstacles. 1997 International Oil Spill Conference. API 4652A. Technical Report IOSC-004.

LGL Ecological Research Associates Inc. 1990. Characterization of the chemosynthetic fauna at Viosca Knoll Block 826. Report for Oryx Energy. 35 pp. + plates.

LGL Ecological Research Associates, Inc. and Texas A&M University. 1986. Gulf of Mexico continental slope study: Annual report, year 2. Volume II: Primary volume. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Office, Metairie, LA. OCS Study MMS 86-0090. 220 pp.

Lin, Q. and I.A. Mendelssohn. 1996. A comparative investigation of the effects of South Louisiana Crude on the vegetation of fresh, brackish and salt marshes. Marine Pollution Bulletin 32:202-209.

Lindstrom, J.E. and J.F. Braddock. 2002. Biodegradation of petroleum hydrocarbons at low temperature in the presence of the dispersant Corexit 9500. Marine Pollution Bulletin 44 (8):739-747. Internet website: http://www.sciencedirect.com/science/journal/0025326X Accessed January 28, 2011.

Lirman, D., G. Deangelo, J. Serafy, A. Hazra, D. Smith Hazra, J. Herlan, J. Lou, S. Bellmund, J. Wang, and R. Clausing. 2008. Seasonal changes in the abundance and distribution of submerged aquatic vegetation in a highly managed coastal lagoon. Hydrobiologia 596:105-120.

Lissner, A.L., G.L. Taghon, D.R. Diener, S.C. Schroeter, and J.D. Dixon. 1991. Recolonization of deep-water hard-substrate communities: Potential impacts from oil and gas development. Ecological Implications 1(3):258-267.

Littler, D.S. and M.M. Littler. 2000. Caribbean reef plants; an identification guide to the reef plants of the Caribbean, Bahamas, Florida and Gulf of Mexico. OffShore Graphics Inc., Florida. Pp. 280-290.

Liu, K-B. and M.L. Fearn. 2000. Holocene history of catastrophic hurricane landfalls along the Gulf of Mexico coast reconstructed from coastal lake and marsh sediments. In: Nig, Z.H. and K.K. Abdollahi, eds. Current stresses and potential vulnerabilities: Implications of global change for the Gulf Coast region of the United States. Baton Rouge, LA: Franklin Press.

Liu, A. and A. Plyer. 2010. The New Orleans Index at Five: An overview of greater New Orleans–from recovery to transformation. Washington: Brookings Institution and Greater New Orleans Community Data Center. 20 pp. Internet website: https://gnocdc.s3.amazonaws.com/NOIat5/Overview.pdf.

Llacuna, S., A. Gorriz, M. Durfort, and J. Nadal. 1993. Effects of air pollution on passerine birds and small mammals. Archives of Environmental Contamination and Toxicology 24:59-66.

Locker, S. 2008. Personal communication. Information concerning the Sticky Mounds 185 km west of Tampa Bay, Florida. Unpublished cruise plan of the Florida Institute of Oceanography, R/V *Bellows*, for October 27-29, 2008. University of South Florida, Dept. of Marine Sciences, St. Petersburg, FL.

Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers. 1990. Association of sea turtles with petroleum platforms in the north-central Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 90-0025. 90 pp.

Lohr, K. 2010. Louisiana Gulf Coast businesses lament losses. National Public Radio. October 13, 2010. Internet website: http://www.npr.org/templates/story/story.php?storyId=130537922. Accessed November 12, 2010.

Long, B.F. and J.H. Vandermuelen. 1983. Geomorphological impact of cleanup of an oiled salt marsh (Ile Grande, France). In: Proceedings, 1983 Oil Spill Conference, February 28-March 3, 1983, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 501-505.

Longley, W.L., ed. 1994. Freshwater inflows to Texas bays and estuaries: Ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin, TX. 386 pp.

Longwell, A.C. 1977. A genetic look at fish eggs and oil. Oceanus 20(4):46-58.

Loren C. Scott & Associates. 2008. The economic impacts of Port Fourchon on the national and Houma MSA economies. 31 pp. Internet website: http://www.portfourchon.com/site100-01/1001757/docs/port_fourchon_economic_impact_study.pdf.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 1993. Coastal Wetland Planning, Protection, and Restoration Act: Louisiana coastal wetlands restoration plan; main report and environmental impact statement. Louisiana Coastal Wetlands Conservation and Restoration Task Force, Baton Rouge, LA.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 2006. The 2006 evaluation report to the U.S. Congress on the effectiveness of Coastal Wetlands Planning, Protection and Restoration Act projects. Submitted by the Chairman of the Louisiana Coastal Wetlands Conservation and Restoration Task Force, U.S. Dept. of the Army, Corps of Engineers, New Orleans District, New Orleans, LA. 73 pp.

Louisiana Dept. of Culture, Recreation, and Tourism. 2010. Louisiana's State parks, historic sites and preservation area. Internet website: http://www.crt.state.la.us/parks/iparkmap.aspx. Accessed April 14, 2011.

Louisiana Dept. of Environmental Quality. 2004. Louisiana environmental inventory report, 2nd annual edition, April 2004. Baton Rouge, LA. 92 pp.

Louisiana Dept. of Environmental Quality. 2010. Louisiana Administrative Code. Title 33: Environmental quality; Part III. Air. Chapter 21: Control of emission of organic compounds. Section 2108: Marine vapor recovery. Pp. 144-146. Internet website: http://www.deq.louisiana.gov/portal/LinkClick.aspx?fileticket=wEHlil1kyQ8%3d&tabid=1674. Accessed April 17, 2011.

Louisiana Dept. of Natural Resources. 1998. Coast 2050: Toward a sustainable coastal Louisiana. Report of the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. Baton Rouge, LA. 173 pp. Internet website: http://www.coast2050.gov/products/docs/orig/2050report.pdf.

Louisiana Dept. of Natural Resources. 2009. Louisiana is proud to be a hub of industry. 6 pp. Internet website: http://dnr.louisiana.gov/assets/docs/hub-of-business_brochure.pdf. Accessed January 23, 2011.

Louisiana Dept. of Natural Resources. 2010. Production information. SONRIS lite. Internet website: http://sonris-www.dnr.state.la.us/www_root/sonris_portal_1.htm. Accessed October 6, 2010.

Louisiana Dept. of Wildlife and Fisheries. 2005. LDWF advises boaters on Lake Pontchartrain and connecting waterways to remain alert for manatees in area. Internet website: http://www.lsu.edu/seagrantfish/news/2005/manatee.htm. Posted August 10, 2005. Accessed December 26, 2010.

Louisiana Dept. of Wildlife and Fisheries. 2008a. The impact of Hurricane Gustav on the fisheries resources of Louisiana: Preliminary report. September 8, 2008. 4 pp.

Louisiana Dept. of Wildlife and Fisheries. 2008b. The impact of Hurricane Ike on the fisheries resources of Louisiana: Preliminary report. October 2, 2008. 5 pp.

Louisiana Dept. of Wildlife and Fisheries. 2009. L.D.W.F. fisheries recovery assessment will benefit commercial fishermen and seafood dealers. News Release, April 17, 2009. Internet website: http://wlf.louisiana.gov/news/30198. Accessed May 18, 2011.

Louisiana Dept. of Wildlife and Fisheries. 2010a. Oyster stock assessment report of the public oyster areas in Louisiana. Oyster Data Report Series No. 16. July, 2010.

Louisiana Dept. of Wildlife and Fisheries. 2010b. Artificial reef program (maps). Internet website: http://www.wlf.louisiana.gov/fishing/artificial-reef-program. Accessed April 15, 2011.

Louisiana Dept. of Wildlife and Fisheries. 2010c. Louisiana fishing regulations 2010—recreational. 48 pp. Internet website: http://www.wlf.louisiana.gov/sites/default/files/pdf/publication/31743-recreational-fishing-regulations/2011_rec_fish.pdf.

Louisiana Mid-Continent Oil and Gas Association. 2010. Impact of President Obama's order halting work on 33 exploratory wells in the deepwater Gulf of Mexico. Internet website: http://www.lmoga.com/Economic%20Impacts%20of%20Gulf%20Moratorium.pdf. Accessed July 7, 2010.

Louisiana Sea Grant. 2006. Louisiana hurricane resources, barrier islands & wetlands. Internet website: http://www.laseagrant.org/hurricane/archive/wetlands.htm. Accessed September 29, 2010.

Louisiana Universities Marine Consortium (LUMCON). 2008. Dead zone again rivals record size. Press Release, July 28, 2008. Internet website: http://www.gulfhypoxia.net/. Accessed May 4, 2009.

Louisiana Universities Marine Consortium (LUMCON). 2009. Gulf of Mexico dead zone surprisingly small in area, but severe. Press Release, July 24, 2009. Internet website: http://www.gulfhypoxia.net/Research/Shelfwide%20Cruises/2009/Files/Press_Release.pdf/. Accessed August 24, 2009.

Louisiana Universities Marine Consortium (LUMCON). 2010a. 2010 Dead zone—one of the largest ever. LUMCON News. Internet website: http://www.lumcon.edu/Information/news/default.asp?XMLFilename=201008021451.xml. Accessed August 10, 2010.

Louisiana Universities Marine Consortium (LUMCON). 2010b. 2010 Dead zone area extends to lower Texas coast. LUMCON News. Internet website: http://www.gulfhypoxia.net/News/default.asp?XMLFilename=201008110954.xml. Accessed November 15, 2010.

Loya, Y. 1975. Possible effects of water pollution on the community structure of Red Sea corals. Marine Biology 29:177-185.

Loya, Y. 1976a. Recolonization of Red Sea corals affected by natural catastrophes and man-made perturbations. Ecology 57:278-289.

Loya, Y. 1976b. Effects of water turbidity and sedimentation on the community structure of Puerto Rican corals. Bulletin of Marine Science 26(4):450-466.

Loya, Y. and B. Rinkevich. 1979. Abortion effect in corals induced by oil pollution. Marine Ecology Progress Series 1:77-80.

Lu, L. and R.S.S. Wu. 2006. A field experimental study on recolonization and succession of macrobenthic infauna in defaunated sediment contaminated with petroleum hydrocarbons. Estuarine, Coastal and Shelf Science 68:627-634.

Lubchenco, J.L., M. McNutt, B. Lehr, M. Sogge, M. Miller, S. Hammond, and W. Conner. 2010. BP *Deepwater Horizon* oil budget: What happened to the oil? Internet website: http://www.noaanews.noaa.gov/stories2010/PDFs/OilBudget_description_%2083final.pdf. Accessed September 8, 2010.

Ludwick, J.C. and W.R. Walton. 1957. Shelf-edge, calcareous prominences in the northeastern Gulf of Mexico. Bulletin of the American Association of Petroleum Geologists 41(9):2054-2101.

Lugo-Fernandez, A., D.A. Ball, M. Gravois, C. Horrell, and J.B. Irion. 2007. Analysis of the Gulf of Mexico's Veracruz-Havana route of La Flota de la Nueva España. Journal of Maritime Archaeology 2(1):24-47.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. In: Lutz, P.L. and J.A. Musick, eds. The biology of sea turtles. Boca Raton, FL: CRC Press, Inc. Pp. 387-409.

Luton, H.H. and R.E. Cluck. 2004. Social impact assessment and offshore oil and gas in the Gulf of Mexico. In: Proceedings, 24th Annual Conference, International Association for Impact Assessment, 24-30 April 2004, Vancouver, Canada.

Lyons, T.J. and W.D. Scott. 1990. Principles of air pollution meteorology. Boca Raton, FL: CRC Press, Inc. 225 pp.

Lytle, J.S. 1975. Fate and effects of crude oil on an estuarine pond. In: Proceedings, Conference on Prevention and Control of Oil Pollution, San Francisco, CA. Pp. 595-600.

Mac, M.J., P.A. Opler, C.E. Puckett Haecker, and P.D. Doran. 1998. Status and trends of the Nation's biological resources: Volume 1 (pp. 1-436). U.S. Dept. of the Interior, Geological Survey, Reston,

VA. P. 391. Internet website: http://www.nwrc.usgs.gov/sandt/SNT.pdf. Accessed September 29, 2010.

MacDonald, I.R., ed. 1992. Chemosynthetic ecosystems study literature review and data synthesis, northern Gulf of Mexico: Volumes I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 92-0033, 92-0034, and 92-0035. 25, 218, and 263 pp., respectively.

MacDonald, I.R., ed. 1998. Stability and change in Gulf of Mexico chemosynthetic communities: Interim report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0034. 114 pp.

MacDonald, I.R., G.S. Boland, J.S. Baker, J.M. Brooks, M.C. Kennicutt II, and R.R. Bidigare. 1989. Gulf of Mexico hydrocarbon seep communities. II. Spatial distribution of seep organisms and hydrocarbons at Bush Hill. Marine Biology 101:235-247.

MacDonald, I.R., N.L. Guinasso, Jr., J.F. Reilly, J.M. Brooks, W.R. Callender, and S.G. Gabrielle. 1990. Gulf of Mexico hydrocarbon seep communities. VI. Patterns in community structure and habitat. Geo-Marine Letters 10:244-252.

MacDonald, I.R., N.L. Guinasso Jr., S.G. Ackleson, J.F. Amos, R. Duckworth, R. Sassen, and J.M. Brooks. 1993. Natural oil slicks in the Gulf of Mexico visible from space. Journal of Geophysical Research 98(C9):16,351-16,364.

MacDonald, I.R., N.L. Guinasso, R. Sassen, J.M. Brooks, S. Lee, and K.T. Scott. 1994. Gas hydrates that breach the sea-floor and intersect with the water column on the continental slope of the Gulf of Mexico. Geology 22:699-702.

MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. 1995. Chemosynthetic ecosystems study: Final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. 319 pp.

MacDonald, I.R., J.F. Reilly Jr., W.E. Best, R. Vnkataramaiah, R. Sassen, N.S. Guinasso Jr., and J. Amos. 1996. Remote sensing inventory of active oil seeps and chemosynthetic communities in the northern Gulf of Mexico. In: Schumacher, D. and M.A. Abrams, eds. Hydrocarbon migration and its near-surface expression. American Association of Petroleum Geologists Memoir 66:27-37.

Mackar, R. 2010. NIH to launch Gulf oil spill health study. Environmental Factor: Your online source for NIEHS news. Internet website: http://www.niehs.nih.gov/news/newsletter/2010/october/spotlight-launch.cfm. Accessed October 2010.

Mackin, J.G. and A.K. Sparks. 1961. A study of the effect on oysters of crude oil loss from a wild well. Publications of the Institute of Marine Science 7:230-261.

Maden, K. and A. Nevala. 2008. Proposals emerge to transfer excess carbon into the ocean. Oceanus Magazine, Woods Hole Oceanographic Institution 46(1):26-27. Internet website: http://www.whoi.edu/oceanus/viewArticle.do?id=35866&sectionid=1000. Accessed January 4, 2010.

Madge, S. and H. Burn. 1988. Waterfowl: An identification guide to the ducks, geese, and swans of the world. Boston, MA: Houghton Mifflin. 298 pp.

Magill, K. 2010. Local jobless rate remains lowest in La. Internet website: http://www.houmatoday.com/article/20101123/ARTICLES/101129790. Accessed December 8, 2010.

Maiaro, J.L. 2007. Disturbance effects on nekton communities of seagrasses and bare substrates in Biloxi Marsh, Louisiana. Master's thesis, Louisiana State University, Baton Rouge, LA. 78 pp. Internet website: http://etd.lsu.edu/docs/available/etd-07032007-101237/unrestricted/Maiaro_thesis.pdf.

Malins, D.C., S. Chan, H.O. Hodgins, U. Varanasi, D.D. Weber, and D.W. Brown. 1982. The nature and biological effects of weathered petroleum. U.S. Dept. of Commerce, National Marine Fisheries

Service, Northwest and Alaska Fisheries Center, Environmental Conservation Division, Seattle, WA. 43 pp.

Malins, D.C., M.M. Krahn, M.S. Myers, L.D. Rhodes, D.W. Brown, C.A. Krone, B.B. McCain, and S-L. Chan. 1985. Toxic chemicals in sediments and biota from a creosote-polluted harbor: relationships with hepatic neoplasms and other hepatic lesions in English sole (*Parophrys vetulus*). Carcinogenesis 6:1463-469.

Mallinson, D.J., A.C. Hine, S.D. Locker, and M.R. Hafen. 1998. The Florida Middle Ground: A complex product of geological, physical, and biological interactions. U.S. Dept. of the Interior, Geological Survey, Center for Coastal Geology. Internet website: http://coastal.er.usgs.gov/wfla/HTML/framework/ofr_f9.htm.

Mallinson, D., B. Donahue, D. Naar, A. Hine, and S. Locker. 2006. Pleistocene and Holocene geologic controls on the Florida Middle Ground relict reef complex: A diverse benthic environment on the West Florida Shelf. 3th Ocean Sciences Meeting, February 2006, Honolulu HI. Internet website: http://www.agu.org/meetings/os06/os06-sessions/os06_OS26I.html. Accessed May 18, 2011.

Mallman, E.P. and M.D. Zoback. 2007. Subsidence in the Louisiana coastal zone due to hydrocarbon production. Proceedings of the 9th International Coastal Symposium, Journal of Coastal Research SI 50:443–449. Gold Coast, Australia. Internet website: http://www.griffith.edu.au/conference/ics2007/pdf/ICS085.pdf.

Malme, C.I., P.W. Smith, and P.R. Miles. 1986. Characterization of geophysical acoustic survey sounds. U.S. Dept. of the Interior, Minerals Management Service, Pacific OCS Region, Los Angeles, CA. OCS Study 86-0032. 92 pp.

Manville II, A.M. 2005. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: State of the art and state of the science—next steps toward mitigation. In: Ralph, C.J. and T.D. Rich, eds. Bird conservation implementation in the Americas: Proceedings of the 3rd International Partners in Flight Conference, 2002. U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA. Forest Service General Technical Report PSW-GTR-191. Pp. 1051-1064.

Manzella, S., J. Williams, B. Schroeder, and W. Teas. 2001. Juvenile head-started Kemp's ridleys found in floating grass mats. Marine Turtle Newsletter 52:5-6.

Marchent, S.R. and M.K. Shutters. 1996. Artificial substrates collect Gulf sturgeon eggs. North American Journal of Fisheries Management 16:445-447.

Marine Resources Research Institute (MRRI). 1984. South Atlantic OCS area living marine resources study: Phase III; final report. Volume 1. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, Washington, DC. Contract No. 14-12-0001-29185. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/4/4622.pdf. 239 pp.

Marine Well Containment Company (MWCC). 2010a. New oil spill containment system to protect Gulf of Mexico planned by major oil companies. Press Release, July 21, 2010. Internet website: http://marinewellcontainment.com/press.php?pressid=1. Accessed December 27, 2010.

Marine Well Containment Company (MWCC). 2010b. ExxonMobil announces equipment for industry use through Marine Well Containment Company. Press Release, September 20, 2010. Internet website: http://www.marinewellcontainment.com/pdfs/MWCC_Early_Response_Equipment_PR_092010_Issued%20092010.pdf. Accessed December 27, 2010.

Marshall, P.A. 2000. Skeletal damage in reef corals: Relating resistance to colony morphology. Marine Ecology Progress Series 200:177-189.

Marszalek, D.S. 1981. Impact of dredging on a subtropical reef community, southeast Florida, USA. In: Proceedings of the Fourth International Coral Reef Symposium. Vol 1. May 18-22, 1981. Manila, Philippines.

Martin, R.P. 1991. Regional overview of wading birds in Louisiana, Mississippi, and Alabama. In: Proceedings of the Coastal Nongame Workshop. U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, and Florida Game and Fresh Water Fish Commission. Pp. 22-33.

Martin, R.P. and G.D. Lester. 1991. Atlas and census of wading bird and seabird nesting colonies in Louisiana: 1990. Louisiana Dept. of Wildlife and Fisheries, Louisiana Natural Heritage Program. Special Publication No. 3.

Mason, J. 2010. The economic cost of a moratorium on offshore oil and gas exploration to the Gulf region. Louisiana State University, Baton Rouge, LA.

Mascarelli, A. 2010. *Deepwater Horizon*: After the oil. Scientific American. Internet website: http://www.scientificamerican.com/article.cfm?id=deepwater-horizon-after-the-oil. Posted September 1, 2010. Accessed December 27, 2010.

Mason, W.T. and J.P. Clugston. 1993. Foods of the Gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 122(3):378-385.

Massachusetts Technology Collaborative. 2005. A framework for offshore wind energy development in the United States. With the U.S. Dept. of Energy, National Renewable Energy Laboratory, and GE Energy. 30 pp. Internet website: http://www.masstech.org/offshore/final_09_20.pdf.

Matthews, T. and B. Cameron, Jr., 2010. OCS regulatory framework for the Gulf of Mexico region. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2010-019. 24 pp. Internet website: http://www.gomr.boemre.gov/PDFs/2010/2010-019.pdf.

Matthiessen, P. and J. P. Sumpter. 1998. Effects of estrogenic substances in the aquatic environment. In: Braunbeck, T., D.E. Hinton, and B. Streit, eds. Fish ecotoxicology. Birkhauser Verlag: Basel, Switzerland.

Maze-Foley, K. and K.D. Mullin. 2006. Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes and interspecific associations. J. Cetacean Res. Manage. 8(2):203-213.

McAuliffe, C.D. 1987. Organism exposure to volatile soluble hydrocarbons from crude oil spills—a field and laboratory comparison. In: Proceedings, 1987 Oil Spill Conference . . . April 6-9, 1988, Baltimore, MD. Washington, DC: American Petroleum Institute. Pp. 275-288.

McAuliffe, C.D., A.E. Smalley, R.D. Groover, W.M. Welsh, W.S. Pickle, and G.E. Jones. 1975. Chevron Main Pass Block 41 oil spill: Chemical and biological investigation. In: Proceedings, 1975 Conference on Prevention and Control of Oil Pollution, March 25-27, 1975, San Francisco, CA. Washington, DC: American Petroleum Institute.

McAuliffe, C.D., B.L. Steelman, W.L. Leek, D.E. Fitzgerald, J.P. Ray, and C.D. Baker. 1981a. The 1979 southern California dispersant treated research oil spills. In: Proceedings 1981 Oil Spill Conference . . . March 2-5, 1981, Atlanta, GA. Washington DC: American Petroleum Institute. Pp. 269-282.

McAuliffe, C.D., G.P. Canevari, T.D. Searl, J.C. Johnson, and S.H. Greene. 1981b. The dispersion and weathering of chemically treated crude oils on the sea surface. In: Petroleum and the Marine Environment. Proceedings of Petromar ’80. London: Graham and Trotman Ltd.

McBride, R.A., S. Penland, M.W. Hiland, S.J. Williams, K.A. Westphal, B.J. Jaffe, and A.H. Sallenger. 1992. Analysis of barrier shoreline change in Louisiana from 1853 to1989. In: Williams, S.J., S. Penland, and A.H. Sallenger, eds. Atlas of shoreline changes in Louisiana from 1853 to 1989. U.S. Dept. of the Interior, Geological Survey. Miscellaneous Investigation Series I-2150-A. P. 36-97.

McCauley, R.D. and R.C. Harrel. 1981. Effects of oil spill cleanup techniques on a salt marsh. In: Proceedings, 1981 Oil Spill Conference . . . March 2-5, 1981, Atlanta, GA. Washington, DC: American Petroleum Institute. Pp. 401-407.

McConnaughey, R.A., K.L. Mier, and C.B. Dew. 2000. An examination of chronic trawling effects on soft-bottom benthos of the eastern Bering Sea. ICES Journal of Marine Science 57:1377-1388.

McCoy, M. and J. Salerno. 2010. Assessing the effects of the Gulf of Mexico oil spill on human health—workshop summary. Institute of Medicine of the National Academies. Pp. 43-74.

McDonald, T.J., J.M. Brooks, and M.C. Kennicutt II. 1984. The effects of dispersant on incorporation of volatile liquid hydrocarbons into the water column. In: Allen. T.E, ed. Oil spill chemical dispersants: Research, experience, and recommendations. ASTM Committee F-20 on Hazardous Substances and Oil Spill Response. ASTM STP 840.

McDonald, S.J., K.L. Willett, J. Thomsen, K.B. Beatty, K. Connor, T.R. Narasimhan, C.M. Erikson, and S.H. Safe. 1996. Sublethal detoxification responses to contaminant exposure associated with offshore production platforms. Canadian Journal of Fisheries and Aquatic Science 53:2606-2617.

McGinnis, M.V., L. Fernandez, C. Pomeroy, S. Hitz, and C. Navarro. 2001. The politics, economics, and ecology of decommissioning offshore oil and gas structures. U.S. Dept. of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. OCS Study MMS 2001-006. 98 pp.

McGrattan, K.B., W.D. Walton, A.D. Putorti Jr., W.H. Twilley, J.A. McElroy, and D.D. Evans. 1995. Smoke plume trajectory from in situ burning of crude oil in Alaska—field experiments. In: Proceedings of the Eighteenth Arctic and Marine Oil spill Program (AMOP) Technical Seminar, Vol. 2, June 14-16, 1995, Edmonton, Alberta, Canada.

McGrail, D. 1982. Water and sediment dynamics at the Flower Garden Banks. In: Norman, R., ed. Environmental studies at the Flower Gardens and selected banks: Northwestern Gulf of Mexico, 1979-1981. Executive summary. Technical Report No. 82-8-T. Pp. 27-29.

McIlgorm, A., H.F. Campbell, and M.J. Rule. 2009. Understanding the economic benefits and costs of controlling marine debris in the APEC region (MRC 02/2007). A report to the Asia-Pacific Economic Cooperation, Marine Resource Conservation Working Group by the National Marine Science Centre (University of New England and Southern Cross University). Coffs Harbour, NSW, Australia. APEC#209-MR-01.3. 95 pp.

McKeithen, M.A. 2007. Testimony to the Committee on Energy and Natural Resources: Hearing on oil and gas resources on the outer continental shelf and areas available for leasing in the Gulf of Mexico, January 25, 2007. Louisiana Dept. of Natural Resources, Office of Mineral Resources. Internet website: http://energy.senate.gov/public/_files/MarjoriesTestimonyFinal2.doc. Accessed February 16, 2011.

McLaughlin, S.L. 1995. Roots, relics, and recovery: What went wrong with the Abandoned Shipwreck Act of 1987. Columbia-VLA Journal of Law & the Arts 19(3):149-198.

McLelland, J.A. and R.W. Heard. 2004. Analysis of benthic macro-invertebrates from northern Florida shallow coastal area where Gulf sturgeon, *Acipenser oxyrinchus desotoi*, are believed to forage. Final report to the U.S. Dept. of the Interior, Fish and Wildlife Service. 27 pp.

McLelland, J.A. and R.W. Heard. 2005. Analysis of benthic macro-invertebrates collected from Gulf sturgeon foraging grounds in northern Florida shallow coastal areas: Year 2. Final report to the U.S. Dept. of the Interior, Fish and Wildlife Service. 26 pp.

MCS Advanced Subsea Engineering. 2010. Risk analysis of using a surface BOP. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 640. 113 pp. + apps. Internet website: http://www.boemre.gov/tarprojects/640/aa.pdf.

McTigue, T.A. and R.J. Zimmerman. 1998. Use of infauna by juvenile *Panaeus aztecus* Ives and *Panaeus setiferus* (Linnaeus). Estuaries 21(1):160-175.

Mechalas, B.J. 1974. Pathways and environmental requirements for biogenic gas production in the ocean. In: Kaplan, I.R., ed. Natural gases in marine sediments. Marine Science, Volume 3. New York, NY: Plenum Press.

Meckel, T.A., U.S. tenBrink, and S.J. Williams. 2006. Current subsidence rates due to compaction of Holocene sediments in southern Louisiana. Geophysical Research Letters Volume 33, L11403. Internet website: http://www.agu.org/pubs/crossref/2006/2006GL026300.shtml.

Melendez, J., J.J. Schubert, and M. Amani. 2006. Risk assessment of surface vs. subsurface BOPs on mobile offshore drilling units. Final project report prepared for the U.S. Dept. of the Interior, Minerals Management Service under the MMS/OTRC Cooperative Research Agreement 1435-01-04-CA-35515. TA&R Project 540. 103 pp. Internet website: http://www.boemre.gov/tarprojects/540/aa.pdf.

Memphis State University. 1971. Effects of noise on wildlife and other animals. Prepared for the U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, DC, under contract number 68-04-0024.

Mendelssohn, I.A. and M.W. Hester. 1988. Texaco USA: Coastal vegetation project, Timbalier Island. New Orleans, LA: Texaco USA. 207 pp.

Mendelssohn, I.A., M.W. Hester, C. Sausser, and M. Fishel. 1990. The effect of a Louisiana crude oil discharge from a pipeline break on the vegetation of a southeast Louisiana brackish marsh. Oil and Chemical Pollution 7:1-15.

Mendelssohn, I.A., M.W. Hester, and J.M. Hill. 1993. Effects of oil spills on coastal wetlands and their recovery. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 93-0045. 46 pp.

Menzies, R.J., R.Y. George, and G.T. Rowe. 1973. Abyssal environment and ecology of the world oceans. Wiley-Interscience. 488 pp.

Meo, S.A. 2009. Effect of duration of exposure to polluted air environment on lung function in subjects exposed to crude oil spill into sea water. International Journal of Occupational Medicine and Environmental Health 22(1):35-41.

Mettee, M.F., T.E. Shepard, J.B. Smith, S.W. McGregor, C.C. Johnson and P.E. O'Neil. 2009. A survey for the Gulf sturgeon in the Mobile and Perdido Basins, Alabama. Geological Survey of Alabama. Open-File Report 0903. 94 pp. Internet website: http://www.gsa.state.al.us/gsa/eco/pdf/OFR_0903.pdf.

Meylan, A.B. and M. Donnelly. 1999. Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of threatened animals. Chelonian Conservation and Biology 3(2):200-204.

Meylan, A. and D. Ehrenfeld. 2000. Conservation of marine turtles. In: Klemens, M.K., ed. Turtle conservation. Washington, DC: Smithsonian Institution Press. Pp. 96-125.

Michel, J. 1992. Chapter 2. Oil behavior and toxicity. In: Hayes, M.O., R. Hoff, J. Michel, D. Scholz, and G. Shigenaka. An introduction to coastal habitats and biological resources for oil spill response. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. NOAA Report No. HMRAD 92-4. Pp. 2-1 through 2-9. Internet website: http://response.restoration.noaa.gov/book_shelf/678_Chapter2.pdf.

Michot, T.C., C.W. Jeske, J.C. Mazourek, W.G. Vermillion, R.S. Kemmerer, and D. Baker. 2003. Atlas and census of wading bird and seabird nesting colonies in South Louisiana, 2001. Barataria-Terrebonne National Estuary Program Report No. 32. Thibodaux, LA. 93 pp.

Mikuska, T., J.A. Kushlan, and S. Hartley. 1998. Key areas for wintering North American herons. Colonial Waterbirds 21:125-134.

Miller, B.K. and W.R. Fontenot. 2001. Birds of the Gulf Coast. Louisiana University Press, Baton Rouge. 132 pp.

Mills, M. 1992. Alaska sport fishing in the aftermath of the *Exxon Valdez* oil spill. Special Report to the Alaska Dept. of Fish and Game Sport Fish Division. 182 pp.

Mississippi Coalition of Vietnamese American Fisherfolk and Families. 2010. Mississippi Coalition preliminary report: Impact of BP oil spill on Vietnamese American communities and seafood industry. Internet website: http://www.mscenterforjustice.org/glomer/upload_repo/docs/MS%20Coalition%20PrelimReport_FINAL_06%2004%2010.pdf. 20 pp. Accessed March 28, 2011.

Mississippi Dept. of Marine Resources. 1999. Mississippi's coastal wetlands. Distributed by Eric Clark, Secretary of State.

Mississippi Dept. of Marine Resources. 2006. Coastal preserves. Internet website: http://www.dmr.state.ms.us/coastal-ecology/preserves/cp-home.htm. Accessed September 29, 2010.

Mississippi Dept. of Marine Resources. 2010a. Rigs-to-reef: Marine fisheries (artificial reef maps). Internet website: http://www.dmr.state.ms.us/Fisheries/Reefs/rigs-to-reef.htm. Accessed April 15, 2011.

Mississippi Dept. of Marine Resources. 2010b. Guide to Mississippi saltwater fishing: Rules and regulations; 2010-2011. 38 pp. Internet website: http://www.dmr.state.ms.us/publications/2010-2011-reg-book.pdf.

Mississippi Development Authority. Tourism Division. 2010. Fiscal year 2009 economic contribution of travel and tourism in Mississippi. 50 pp. Internet website: http://www.visitmississippi.org/resources/FY2009_Economic_Contribution_Report_and_Cover.pdf.

Mississippi Press. 2007. Sees salt dome as worst disaster since Katrina. News article. Internet website: http://www.gulflive.com/opinion/mississippipress/index.ssf?/base/opinion/119538457290590.xml. Accessed November 19, 2007.

Mitchell, H. 2010. Personal communication. Vulnerability of beach mice to damage of burrows by cleanup personnel. Wildlife Biologist, U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services Office, Panama City, FL.

Mitchell, R. and I. Chet. 1975. Bacterial attack of corals in polluted seawater. Microbial Ecology 2:227-233.

Mitchell, R., I.R. MacDonald, and K.A. Kvenvolden. 1999. Estimation of total hydrocarbon seepage into the Gulf of Mexico based on satellite remote sensing images. Transactions, American Geophysical Union 80(49), Ocean Sciences Meeting, OS242.

Mitsch, W.J. and J.G. Gosselink. 2007. Wetlands. Hoboken, NY: John Wiley and Sons.

Moncreiff, C.A. 2007. Statewide summary for Mississippi. In: Handley, D.A, D. Altsman, and R. DeMay, eds. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. Pp. 73-76. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed May 13, 2011.

Montagna, P.A. and D.E. Harper, Jr. 1996. Benthic infaunal long-term response to offshore production platforms in the Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 53:2567-2588.

Montagna, P. and T. Holmberg. 2000. Epibiont recruitment. In: McKay, M. and J. Nides. 2000. Proceedings: Eighteenth Annual Gulf of Mexico Information Transfer Meeting. December 1998. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-030. Pp. 347-352.

Montagna, P.A. and J. Li. 1997. Modeling contaminant effects on deposit feeding nematodes near Gulf of Mexico production platforms. Ecological Modeling 98:151-162.

Moore, S.F. 1976. Offshore oil spills and the marine environment. Technology Review 61-67.

Moore, J.J. 2006. State of the marine environment in SW Wales, 10 years after the *Sea Empress* oil spill. Prepared for Countryside Council for Wales. Marine Monitoring Report No. 21.

Moore, D.R. and H.R. Bullis, Jr. 1960. A deep-water coral reef in the Gulf of Mexico. Bulletin of Marine Science 10(1):125-128.

Moore, S.F. and R.L. Dwyer. 1974. Effects of oil on marine organisms: A critical assessment of published data. Water Research 8:819-827.

Moridis, G.J., T.S. Collett, R. Boswell, M. Kurihara, M.T. Reagan, C. Koh, and E.D. Sloan. 2008. Toward production from gas hydrates: Current status, assessment of resources, and simulation-based evaluation of technology and potential. Society of Petroleum Engineers. Unconventional Reservoirs Conference, Keystone, CO, February 10-12, 2008. 43 pp. Internet website: http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/reports/G308_SPE114163_Feb08.pdf.

Morita A., Y. Kusaka, Y. Deguchi, A. Moriuchi, Y. Nakanaga, M. Iki, S. Miyazaki, and K. Kawahara. 1999. Acute health problems among the people engaged in the cleanup of the Nakhodka oil spill. Environmental Research 91:185-194.

Morrison, R.I.G. 1984. Migration systems of some New World shorebirds. In: Burger, J. and B.L. Olla, eds. Shorebirds: Migration and foraging behavior. Behavior of marine animals. Current Perspectives in Research 6:125-206.

Morrison, R.I.G., R.E. Gill, Jr., B.A. Harrington, S. Skagen, G.W. Page, C.L. Gratto-Trevor, and S.M. Haig. 2000. Population estimates of Nearctic shorebirds. Waterbirds 23:337-352.

Morrison, R.I.G., R.E. Gill, Jr., B.A. Harrington, S. Skagen, G.W. Page, C.L. Gratto-Trevor, and S.M. Haig. 2001. Estimates of shorebird populations in North America. Canadian Wildlife Service Occasional Paper No. 104, Ottawa, Ontario.

Morrison, R.I.G., B.J. McCaffery, R.E. Gill, S.K. Skagen, S.L. Jones, G.W. Page, C.L. Gratto-Trevor, and B.A. Andres. 2006. Population estimates of North American shorebirds. Wader Study Group Bulletin 111:67-85.

Morton, R.A. 1982. Effects of coastal structures on shoreline stabilization and land loss—the Texas experience. In: Boesch, D.F., ed. Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. Washington, DC: U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/59.

Morton, R.A. 2003. An overview of coastal land loss: With emphasis on the southeastern United States. U.S. Dept. of the Interior, Geological Survey. USGS Open File Report 03-337. Internet website: http://pubs.usgs.gov/of/2003/of03-337/intro.html. Accessed May 11, 2010.

Morton, R.A. 2008. Historical changes in the Mississippi-Alabama barrier-island chain and the roles of extreme storms, sea level, and human activities. Journal of Coastal Research 24(6):1587-1600. West Palm Beach (Florida), ISSN 0749-0208.

Morton, R.A., N. Buster, and M. Krohn. 2002. Subsurface controls on historical subsidence rates and associated wetland loss in south-central Louisiana. Transactions Gulf Coast Association of Geological Societies 52:767-778.

Morton, R.A., J.C. Bernier, J.A. Barras, and N.F. Ferina. 2005. Rapid subsidence and historical wetland loss in the Mississippi Delta plain: Likely causes and future implications. U.S. Dept. of the Interior, Geological Survey. Open-File Report 2005-1216. 116 pp. Internet website: http://pubs.usgs.gov/of/2005/1216/ofr-2005-1216.pdf.

Mosier, A.E. 1998. The impact of coastal armoring structures on sea turtle nesting behavior at three beaches on the East Coast of Florida. Unpublished Masters thesis, University of South Florida, St. Petersburg, FL. 112 pp.

Moyers, J.E. 1996. Food habits of Gulf Coast subspecies of beach mice (*Peromyscus polionotus* spp.). M.S. Thesis, Auburn University, AL. 84 pp.

Muller-Karger, F.E., F. Vukovich, R. Leben, B. Nababan, C. Hu, and D. Myhre. 2001. Surface circulation and the transport of the Loop Current into the northeastern Gulf of Mexico: Final report.

U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-102. 39 pp.

Mullin, K.D. and W. Hoggard. 2000. Visual surveys of cetaceans and sea turtles from aircraft and ships; Chapter 4. In: Davis, R.W., W.E. Evans, and B. Würsig, eds. Cetaceans, sea turtles and birds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report. U.S. Dept. of the Interior, Geologic Survey, Biological Resources Division, USGS/BRD/CR-1999-005 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-003. 364 pp.

Murray, S.P. 1998. An observational study of the Mississippi/Atchafalaya coastal plume: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0040. 513 pp.

Murray, S.P. and J. Donley. 1996. Mississippi River plume hydrography: Second annual report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 96-0022. 175 pp.

Nalco. 2010. Oil dispersant expert testimony. Internet website. http://www.nalco.com/news-and-events/4259.htm. Accessed December 27, 2010.

National Association of Corrosion Engineers (NACE). 2003. Standard material requirements—methods for sulfide stress cracking and stress corrosion cracking resistance in sour oilfield environments. National Association of Corrosion Engineers. ANSI/NACE MR1075-2003. 44 pp. Internet website: http://www.techstreet.com/cgi-bin/detail?doc_no=NACE%7CMR0175_2003&product_id=1082002.

National Geographic Society. 1999. Field guide to the birds of North America, third edition. Washington, DC: National Geographic. 480 pp.

National Research Council (NRC). 1983. Drilling discharges in the marine environment. Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment. Marine Board, Commission on Engineering and Technical Systems, National Research Council. Washington, DC: National Academy Press. Pp. 18-21.

National Research Council (NRC). 1985. Oil in the sea—inputs, fates and effects. Washington, DC: National Academy Press. 601 pp.

National Research Council (NRC). 1989. Using oil spill dispersants on the sea. Washington, DC: National Academy Press. 335 pp.

National Research Council (NRC). 1990. Decline of the sea turtles: Causes and prevention. Committee on Sea Turtle Conservation. Washington, DC: National Academy Press. 280 pp.

National Research Council (NRC). 2002. Effects of trawling & dredging on seafloor habitat. Washington, DC: National Academy Press. 136 pp.

National Research Council (NRC). 2003. Oil in the sea III: Inputs, fates, and effects (Committee on Oil in the Sea: J.N. Coleman, J. Baker, C. Cooper, M. Fingas, G. Hunt, K. Kvenvolden, J. McDowell, J. Michel, K. Michel, J. Phinney, N. Rabalais, L. Roesner, and R.B. Spies). Washington, DC: National Academy Press. 265 pp.

National Research Council (NRC). 2005. Oil spill dispersants: Efficacy and effects. Washington, DC: National Academy Press. 377 pp.

National Research Council (NRC). 2006. Review of recreational fisheries survey methods. Washington, DC: National Academy Press. 202 pp.

National Resources Defense Council. 2010. Disaster in the Gulf: Tracking oil washing ashore on beaches. Internet website: http://www.nrdc.org/energy/gulfspill/beaches.asp. Accessed April 18, 2011.

National Response Team. 2010. Oil spill response strategies for coastal marshes during the *Deepwater Horizon* MC252 spill. 10 pp. Internet website: http://www.nrt.org/Production/NRT/NRTWeb.nsf/

AllAttachmentsByTitle/SA-1061NRT_Marsh_Cleanup_Options_DWH.06032010.pdf/$File/NRT_marsh_cleanup_overview_6-15.pdf?OpenElement. Accessed December 23, 2010.

National Wetlands Inventory Group. 1985. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950's to 1970's. Trans. N. Am. Wildl. Nat. Resour. Conf. 50:440-448.

Natural Resources Defense Council. 2010. Gulf Coast seafood consumption survey. Internet website: http://docs.nrdc.org/health/files/hea_10120702a.pdf. 7 pp.

NaturalGas.org. 2010a. Offshore drilling. Internet website. http://www.naturalgas.org/naturalgas/extraction_offshore.asp. Accessed December 21, 2010.

NaturalGas.org. 2010b. Background. Internet website: http://www.naturalgas.org/overview/background.asp. Accessed August 25, 2010.

Neal Adams Firefighters Inc. 1991. Joint industry program for floating vessel blowout control. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 150. Internet website: http://www.boemre.gov/tarprojects/150/150AA.pdf.

Neff, J.M. 1990. Composition and fate of petroleum and spill-treating agents in the marine environment. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 1-33.

Neff, J.M. 2002. Bioaccumulation in marine organisms: Effect of contaminants from oil well produced water. Kidlington, Oxford, UK: Elsevier Science Ltd.

Neff, J.M. 2005. Composition, environmental fates, and biological effects of water based drilling muds and cuttings discharged to the marine environment: A synthesis and annotated bibliography. Prepared for the Petroleum Environmental Research Forum and American Petroleum Institute. Duxbury, MA: Battelle. 83 pp. Internet website: http://www.perf.org/pdf/APIPERFreport.pdf.

Neff, J.M., T.C. Sauer, and N. Maciolek. 1989. Fate and effects of produced water discharges in nearshore marine waters. Prepared for the American Petroleum Institute, Washington, DC.

Neff, J.M. and T.C. Sauer, Jr. 1991. Review: Findings of the American Petroleum Institute study on produced waters. In: Geo-Marine, Inc. Proceedings: Eleventh Annual Gulf of Mexico Information Transfer Meeting. November, 1990. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 91-0040. 524 pp.

Neff, J.M., S. McKelvie, and R.C. Ayers, Jr. 2000. Environmental impacts of synthetic-based drilling fluids. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-064. 118 pp.

Nelson, H.F. and E.E. Bray. 1970. Stratigraphy and history of the Holocene sediments in the Sabine-High Island Area, Gulf of Mexico. In: Morgam, J.P., ed. Deltaic sedimentation; modern and ancient. Special Publn. No. 15. Tulsa, OK: SEPM.

Nelson, D.L. and M.M. Cox. 2008. Lehringer principles of biochemistry, fifth edition. W.H. Freeman. 1,100 pp.

Netto, S.A., F. Gallucci, and G. Fonseca. 2009. Deep-sea meiofauna response to synthetic-based drilling mud discharge off SE Brazil. Deep-Sea Research II 56:41-49.

Neumann, C.J., B.R. Jarvinen, and J.D. Elms. 1993. Tropical cyclones of the north Atlantic Ocean, 1871-1992. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Asheville, NC. 193 pp.

Newell, R.C., L.J. Seiderer, and D.R. Hitchcock. 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. Oceanography and Marine Biology: An Annual Review 36:127-178.

Newman, J.R. 1977. Sensitivity of the hose martin (*Delichon urbica*) to fluoride emissions. Fluoride 10:73-76.

Newman, J.R. 1980. Effects of air emissions on wildlife resources. U.S. Dept. of the Interior, Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-80/40.1. 32 pp.

Newman, S.H., A. Chmura, K. Converse, A.M. Kilpatrick, N. Patel, E. Lammers, and P. Daszak. 2007. Aquatic bird disease and mortality as an indicator of changing ecosystem health. Marine Ecology Progress Series 352:299-309.

Nicholls, J.L. and G.A. Baldassarre. 1990. Habitat associations of piping plovers wintering in the United States. Wilson Bulletin 102:581-590.

Nicol, J.A.C., W.H. Donahue, R.T. Wang, and K. Winters. 1977. Chemical composition and effects of water extracts of petroleum and eggs of the sand dollar *Melitta quinquiesperforata*. Marine Biology 40:309-316.

Nisbet, I.C.T. 2000. Disturbance, habituation, and management of waterbird colonies. Waterbirds 23:312-332.

Nolan, B. 2010. Family business knocked to its knees by oil spill, moratorium. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/09/family_business_knocked_to_its.html. Accessed December 12, 2010.

Nolan, B. and A. Good. 2010. Moratorium in wake of Gulf oil spill idles much more than rigs, workers. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/07/moratorium_in_wake_of_gulf_oil.html. Accessed July 6, 2010.

Norris, F.H., S.P. Stevens, B. Pfefferbaum, K.F. Wyche, and R. L. Pfefferbaum. 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. American Journal of Community Psychology 41:127-150.

Nowlin, W.D., Jr. 1972. Winter circulation patterns and property distributions. In: Capurro, L.R.A. and J.L. Reid, eds. Contributions on the physical oceanography of the Gulf of Mexico. Texas A&M University Oceanographic Studies, Vol. 2. Houston, TX: Gulf Publishing Co. Pp. 3-51.

Nowlin, W.D., Jr., A.E. Jochens, R.O. Reid, and S.F. DiMarco. 1998. Texas-Louisiana shelf circulation and transport processes study: Synthesis report. Volume I: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0035. 502 pp.

Nudds, T.D. 1983. Niche dynamics and organization of waterfowl guilds in variable environments. Ecology 64:319-330.

Nudds, T.D. 1992. Patterns in breeding waterfowl communities. In: Afton, A.D., M.G. Anderson, C.D. Ankney, D.H. Johnson, J.A. Kadlec, and G.L. Krapu, eds. Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis. Pp. 540-547.

Nunley, M.J. 2010. Gulf sturgeon annual workshop meeting. Presentation: VR2W receiver deployment in the Gulf of Mexico. Science Applications International Corporation.

O'Conner, J.M. and R.J. Huggett. 1998. Aquatic pollution problems, North Atlantic coast, including Chesapeake Bay. Aquat. Toxicol. 11:163-190.

Odenkirk, J.S. 1989. Movements of Gulf of Mexico sturgeon in the Apalachicola River, Florida. In: Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 43:230-238.

Odess, D. 2010. Personal communication. Teleconference regarding Section 106 in relation to response to the oil spill.

offshoreWIND.biz. 2010. Japan plans to build 1,000MW offshore wind power by 2020. Internet website: http://www.offshorewind.biz/2010/05/10/japan-plans-to-build-1000mw-offshore-wind-power-by-2020/. Posted May 10, 2010. Accessed March 24, 2011.

Ogren, L.H. 1989. Distribution of juvenile and sub-adult Kemp's ridley sea turtle: Preliminary results from 1984-1987 surveys. In: Caillouet, C.W. and A.M. Landry, eds. First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, Texas A&M University; Galveston, TX, October 1-4, 1985. TAMU-SG-89-105. Pp. 116-123.

O'Hara, P.D. and L.A. Morandin. 2010. Effects of sheens associated with offshore oil and gas development on the feather microstructure of pelagic seabirds. Marine Pollution Bulletin 60:672-678.

Oil and Gas Journal. 2009. BP finds oil in multiple Lower Tertiary reservoirs. Internet website: http://www.ogfj.com/index/article-display/5015598529/articles/oil-gas-financial-journal/volume-6/Issue_10/Upstream_News/BP_finds_oil_in_multiple_Lower_Tertiary_reservoirs.html. Posted October 1, 2009. Accessed January 11, 2011.

Oil Spill Commission. 2011a. Response/clean-up technology research & development and the BP *Deepwater Horizon* oil spill. Staff Working Paper No. 7. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Originally released November 22, 2010; updated January 11, 2011. 28 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Response%20RD%20Working%20Paper.pdf. Accessed February 11, 2011.

Oil Spill Commission. 2011b. Stopping the spill: The five-month effort to kill the Macondo well. Staff Working Paper No. 6. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Containment%20Working%20Paper.pdf. Posted November 22, 2010. Updated January 11, 2011.

Oil Spill Commission. 2011c. Deep water: The Gulf oil disaster and the future of offshore drilling. Report to the President, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Recommendations for Decisionmakers. January 2011. 63 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/OSC_Deep_Water_Summary_Recommendations_FINAL.pdf.

O'Keefe, D.J. and G.A. Young. 1984. Handbook on the environmental effects of underwater explosives. U.S. Dept. of the Navy, Naval Surface Warfare Center, Dahlgren, VA, and Silver Spring, MD. NSWC TR 83-240.

Olsen, K.M. and H. Larsson. 1995. Terns of Europe and North America. Princeton, NJ: Princeton University Press. 175 pp.

Olsen, K.M. and H. Larsson. 1997. Skuas and jaegers. New Haven, CT: Yale University Press. 190 pp.

Onuf, C.P. 1994. Seagrasses, dredging and light in Laguna Madre, Texas, U.S.A. Estuarine Coastal Shelf Science 39:75-91.

Onuf, C.P. 1996. Biomass patterns in seagrass meadows of the Laguna Madre, Texas. Bulletin of Marine Science 58(2):404-420.

Orth, R.J., T.J.B. Carruthers, W.C. Dennison, C.M. Duarte, J.W. Fourqurean, K.L. Heck, Jr., A.R. Hughes, G.A. Kendrick, W.J. Kenworthy, S. Olyarnik, F.T. Short, M. Waycott, and S.L. Williams. 2006. A global crisis for seagrass ecosystems. BioScience 56(12):987-996.

Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, and D. Canestro. 1992. Spatial scale of ecological effects associated with and open coast discharge of produced water. In: Ray, J.P. and F.R. Englehardt, eds. Produced water: Technological/environmental issues and solutions. New York, NY: Plenum Press. Pp. 387-402.

Otvos, E.G. 1979. Barrier island evolution and history of migration: North central Gulf Coast. In: Leatherman, S., ed. Barrier islands from the Gulf of St. Lawrence to the Gulf of Mexico. New York, NY: Academic Press. Pp. 219-319.

Overpeck, J.T., B.L. Otto-Bliesner, G.H. Miller, D.R. Muhs, R.B. Alley, and J.T. Kiehl. 2006. Paleoclimatic evidence for future ice-sheet instability and rapid sea-level rise. Science 311(5768):1747–1750.

Oxford Economics. 2010. Potential impact of the Gulf oil spill on tourism. Prepared for the U.S. Travel Association. 27 pp. Internet website: http://www.ustravel.org/sites/default/files/page/2009/11/Gulf_Oil_Spill_Analysis_Oxford_Economics_710.pdf.

Oynes, C. 2006. Deepwater expansion continues in the Gulf of Mexico. Pipeline & Gas Journal 231(6):58.

Palinkas, L.A., A.J. Russell, M.A. Downs, and J.S. Petterson. 1992. Ethnic-differences in stress, coping, and depressive symptoms after the *Exxon Valdez* oil-spill. Journal of Nervous and Mental Disease 180:287-295.

Palka, D. and M. Johnson, eds. 2007. Cooperative research to study dive patterns of sperm whales in the Atlantic Ocean. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-033. 49 pp.

Parauka, F. 2007a. Personal communication. Post-Katrina recovery of Gulf sturgeon habitat. U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services, Fisheries Resource Office, Panama City FL.

Parauka, F. 2007b. Personal communication. Information concerning the critical habitat, sampling programs, and damage assessments of the Gulf sturgeon. U.S. Dept. of the Interior, Fish and Wildlife Service, Ecological Services, Fisheries Resource Office, Panama City FL. May 29, 2007.

Parauka, F. 2008. Personal communication. Gulf sturgeon population survey in the Escambia River, Florida. AFA News, Newsletter of the Alabama Fisheries Association, January 2007.

Parker, P.L., G.P. Pfeiffer, R.E. Casey, C.S. Giam, J.S. Holland, E.T. Park, B.J. Presley, W.M. Sackett, N.P. Smith, C. Van Baalen, and D.E. Wohlschlang. 1975. Environmental assessment of the south Texas outer continental shelf. Chemical and biological survey component. Report to the U.S. Dept. of the Interior, Bureau of Land Management. Contract no. 08550-CT5-17.

Parker, R.O., Jr., D.R. Colby, and T.P. Willis. 1983. Estimated amount of reef habitat on a portion of the U.S. South Atlantic and Gulf of Mexico continental shelf. Bulletin of Marine Science 33:935-940.

Parkyn, D.C., D.J. Murie, J.E. Harris, D.E. Colle, and J.D. Holloway. 2007. Seasonal movements of Gulf of Mexico sturgeon in the Suwannee River and estuary. American Fisheries Society Symposium 56**:**51-68.

Parnell, J.F., D.G. Ainley, H. Blokpoel, G. Cain, T.W. Custer, J.L. Dusi, S. Kress, J.A. Kushlan, W.E. Southern, L.E. Stenzel, and B.C. Thompson. 1988. Colonial waterbird management in North America. Journal of the Colonial Waterbird Society 11:129-169.

Parr, A.E. 1939. Quantitative observations on pelagic Sargassum vegetation of the western North Atlantic. Bull. Bingham Oceanog. Coll. 6:1-94

Parsons, J.J. 1972. The hawksbill turtle and the tortoise shell trade. In: Études de géographie tropicale offertes a Pierre Gourou. Paris, France: Mouton. Pp. 45-60.

Parsons, K.C. 1994. The Arthur Kill oil spills: Biological effects in birds. In: Burger, J., ed. Before and after an oil spill: The Arthur Kill. New Brunswick, NJ: Rutgers University Press. Pp. 215-237.

Parsons, G. and A. Kang. 2007. Valuing beach closures on the Padre Island National Seashore. University of Delaware, Graduate College of Marine Studies. U.S. Dept. of Commerce, NOAA Grant Number NA04NOS4190063. Project Number 06-090. 31 pp.

Pashley, D.N. 1991. Shorebirds, gulls, and terns: Louisiana, Mississippi, Alabama. In: Proceedings of the Coastal Nongame Workshop. U.S. Dept. of the Interior, Fish and Wildlife Service, Region 4, and Florida Game and Fresh Water Fish Commission. Pp. 79-83.

Patin, S.A. 1999. Environmental impact of the offshore oil and gas industry. East Northpoint, NY: EcoMonitor Publishing. Pp. 425.

Patrick, S.R., D.R. Patrick, and S.W. Fardo. 1993. Energy conservation guidebook. Lilburn, GA: The Fairmont Press, Inc. 471 pp. Internet website: http://books.google.com/books?id=f45IIzt4DCIC&pg=PA143&lpg=PA143&dq=ship,+%22discharge+water+temperature%22&source=bl&ots=CEHy0wpaMz&sig=BZam0pB-2mDwo4vO5zGM9jBsQWY&hl=en&ei=nMEpTYnqJsSBlAf_-7joAQ&sa=X&oi=book_result&ct=result&resnum=5&ved=0CC0Q6AEwBA#v=onepage&q&f=false. Accessed January 10, 2011.

Pattengill, C.V. 1998. The structure and persistence of reef fish assemblages of the Flower Garden Banks National Marine Sanctuary. Ph.D. Thesis, Texas A&M University, College Station, TX.

Paull, C.K., B. Hecker, R. Commeau, R.P Freeman-Lynde, C. Neumann, W.P. Corso, S. Golubic, J.E. Hook, E. Sikes, and J. Curry. 1984. Biological communities at the Florida Escarpment resemble hydrothermal vent taxa. Science 226:965-967.

PCCI Marine and Environmental Engineering. 1999. Oil spill containment, remote sensing and tracking for deepwater blowouts: status of existing and emerging technologies. Report prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 311. 66 pp. + apps. Internet website: http://www.boemre.gov/tarprojects/311/311AA.pdf.

Peakall, D.B., P.G. Wells, and D. Mackay. 1987. A hazard assessment of chemically dispersed oil spills and seabirds. Marine Environmental Research 22:91-106.

Peakall, D.B., R.J. Norstrom, D.A. Jeffrey, and F.A. Leighton. 1989. Induction of hepatic mixed function oxidases in the herring gull (*Larus argentatus*) by Pruhoe Bay crude oil and its fractions. Comparative Biochemistry and Physiology 94C:461-463.

Peake, D., G. Fargion, K. Mullen, and R. Pitman. 1995. Seabirds of the northwestern and central Gulf of Mexico. In: Abstracts of the Joint Meeting of the Wilson Ornithological Society and Virginia Society of Ornithology, Virginia, 4-7 May, 1995.

Pearson, C.E., D.B. Kelley, R.A. Weinstein, and S.W. Gagliano. 1986. Archaeological investigations on the outer continental shelf: A study within the Sabine River valley, offshore Louisiana and Texas. U.S. Dept. of the Interior, Minerals Management Service, Reston, VA. OCS Study MMS 86-0119. 314 pp.

Pearson, C.E., S.R. James, Jr., M.C. Krivor, S.D. El Darragi, and L. Cunningham. 2003. Refining and revising the Gulf of Mexico outer continental shelf region high-probability model for historic shipwrecks: Final report. Volume I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-060, 2003-061, and 2003-062. 13, 338, and 138 pp., respectively.

Peele, R.H., J.I. Snead, and W. Feng. 2002. Outer continental shelf pipelines crossing the Louisiana coastal zone: A geographic information system approach. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region OCS Study, New Orleans LA. MMS 2002-038. 24 pp.

Penland, S., L. Wayne, L.D. Britsch, S.J. Williams, A.D. Beall, and V. Caridas Butterworth. 2001a. Geomorphic classification of coastal land loss between 1932 and 1990 in the Mississippi River Delta Plain, southeastern Louisiana. U.S. Dept. of the Interior, Geological Survey, Coastal and Marine Geology Program, Woods Hole Field Center, Woods Hole, MA. Open-File Report 00-417.

Penland, S., L. Wayne, L.D. Britsch, S.J. Williams, A.D. Beall, and V. Caridas Butterworth. 2001b. Process classification of coastal land loss between 1932 and 1990 in the Mississippi River Delta Plain, southeastern Louisiana. U.S. Dept. of the Interior, Geological Survey, Coastal and Marine Geology Program, Woods Hole Field Center, Woods Hole, MA. Open-File Report 00-418.

Pequegnat, W.E. 1983. The ecological communities of the continental slope and adjacent regimes of the northern Gulf of Mexico. Prepared by TerEco Corp. for the U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 398 pp.

Pequegnat, W.E., B.J. Gallaway, and L. Pequegnat. 1990. Aspects of the ecology of the deepwater fauna of the Gulf of Mexico. American Zoologist 30:45-64.

Perez, C., A. Velando, I. Munilla, M. Lopez-Alonzo, and D. Oro. 2008. Monitoring polycyclic aromatic hydrocarbon pollution in the marine environment after the *Prestige* oil spill by means of seabird blood analysis. Environmental Science and Technology 42:707-713.

Perez, C., I. Munilla, M. Lopez-Alonso, and A. Velando. 2010. Sublethal effects on seabirds after the *Prestige* oil-spill are mirrored in sexual signals. Biological Letters 6:33-35.

Peters, E.C., P.A. Meyers, P.P. Yevich, and N.J. Blake. 1981. Bioaccumulation and histopathological effects of oil on a stony coral. Marine Pollution Bulletin 12(0):333-339.

Peters, E.C., N.J. Gassman, J.C. Firman, R.H. Richmond, and E.A. Power. 1997. Ecotoxicology of tropical marine ecosystems. Environmental Toxicology and Chemistry 16(1):12-40.

Peterson, C.H., M.C. Kennicutt II., R.H. Green, P. Montagna, D.E. Harper, Jr., E.N. Powell, and P.F. Roscigno. 1996. Ecological consequences of environmental perturbations associated with offshore hydrocarbon production: A perspective on long-term exposures in the Gulf of Mexico. Canadian Journal of Fisheries and Aquatic Science 53:2637-2654.

Pezeshki, S.R., R.D. Delaune, J.A. Nyman, R.R. Lessard, and G.P. Canevari. 1995. Removing oil and saving oiled marsh grass using shoreline cleaner (Publication No. 4620). International Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 203-209.

Pezeshki, S.R., M.W. Hester, Q. Lin, and J.A. Nyman. 2000. The effects of oil spill and cleanup on dominant U.S. Gulf Coast marsh macrophytes: A review. Environmental Pollution 108:129-139.

Pfeffer, W.T., J.T. Harper, and S. O'Neel. 2008. Kinematic constraints on glacier contributions to 21st-century sea-level rise. Science 321(5894):1340–1343.

Pielke, R.A., Jr., C. Landsea, M. Mayfield, J. Laver, and R. Pasch. 2005. Hurricanes and global warming. American Meteorological Society 86(11):171–175.

Pine, W.E. and S. Martell. 2009. Status of Gulf sturgeon in Florida waters: A reconstruction of historical population trends to provide guidance on conservation targets. March 31, 2009, draft final report, project number NG06-004, University of Florida project number 00065323, contract number 06108. 47 pp.

Pine, W.E., H.J. Flowers, K.G. Johnson, and M.L. Jones. 2006. An assessment of Gulf sturgeon movement, spawning site selection, and post-spawn holding areas in the Apalachicola River, Florida. Final report submitted to the Florida Fish and Wildlife Conservation Commission. University of Florida, Gainesville, FL. 104 pp.

Pipelines International. 2010. Getting the job done in swamp, marsh and wetland terrain. December 2010. Vol. 006, pp. 34-35. Internet website: http://pipelinesinternational.com/pdfs/PIN_Dec10_web.pdf.

Plyer, A. and R. Campanella. 2010. Coastal employment before the 2010 *Deepwater Horizon* oil disaster.: Employment maps and data from 2008. Greater New Orleans Community Data Center. Internet website: https://gnocdc.s3.amazonaws.com/reports/GNOCDC_CoastalEmployment.pdf. Released July 20, 2010. 12 pp.

Poirier, O.A. and G.A. Thiel. 1941. Deposition of free oil by sediments settling in sea water. Bulletin of the American Association of Petroleum Geologists 25(12):2170-2180.

Poirrier, M.A. 2007. Statewide summary for Louisiana. In: Handley, D.A, D. Altsman, and R. DeMay, eds. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. U.S. Dept. of the Interior, Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. 61 pp. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed May 13, 2011.

Pomponi, S.A. 2010. Cruise plan. Florida shelf edge exploration: Rapid response to the *Deepwater Horizon* oil spill. Update: July 4, 2010. Cooperative Institute for Ocean Exploration, Research, and Technology, Harbor Branch at Florida Atlantic University.

Pond, S. and G.L. Pickard. 1983. Introductory dynamical oceanography, 2nd ed. New York, NY: Pergamon Press. 329 pp.

Powell, E.N. 1995. Evidence for temporal change at seeps. In: MacDonald, I.R., W.W. Schroeder, and J.M. Brooks, eds. Chemosynthetic ecosystems study: Final report. Volume 2: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0022. Pp. 8.1-8.65.

Powell II, A. 2010. Barataria Bay oil spill enters cleanup mode. *The Times Picayune*, August 3, 2010. Internet website: http://blog.nola.com/news_impact/print.html?entry=/2010/08/barataria_bay_oil_spill_enters.html. Accessed December 28, 2010.

Poysa, H. 1983. Morphology-mediated niche organization in a guild of dabbling ducks. Ornis Scandinavica 14:317-326.

Precht, W.F., R.B. Aronson, K.J.P. Deslarzes, M.L. Robbart, D.J. Evans, B. Zimmer, and L. Duncan. 2008. Long-term Monitoring at the East and West Flower Garden Banks, 2004-2005: Interim report. Volume I: Technical report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 2008-027. 123 pp.

Prentki, R.T., C. Smith, O. Johansen, P. Daling, M. Moldestad, K. Skognes, and M. Reed. 2004. The MMS/SINTEF oil weathering model, further development and applications. Review version of paper presented at International Marine Environmental Modeling Seminar (IMEMS), Washington, DC, October 2004. Internet website: http://alaska.boemre.gov/reports/2005rpts/2005_020/Final%20Report/Appendix%20E/prentki_OWM_Alaska.pdf.

Pritchard, P.C.H. 1997. Evolution, phylogeny, and current status. In: Lutz, P.L. and J.A. Musivk, eds. The biology of sea turtles. Boca Raton, FL: CRC Press. Pp. 1-28.

Puder, M.G. and J.A. Veil. 2006. Offsite commercial disposal of oil and gas exploration and production waste: Availability, options, and costs. Argonne National Laboratory, Environmental Science Division. Internet website: http://www.evs.anl.gov/pub/doc/ANL-EVS-R-06-5.pdf.

Pulsipher, A.G., O.O. Iledare, R.H. Baumann, D.E. Dismukes, and D.V. Mesyanzhinov. 1998. Environmental and safety risks of an expanding role for independents on the Gulf of Mexico OCS. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0021. 39 pp.

Rabalais, N.N. 1990. Biological communities of the south Texas continental shelf. American Zoologist 30:77-87.

Rabalais, N.N., R.E. Turner, and W.J. Wiseman, Jr. 2002. Gulf of Mexico hypoxia, A.K.A. "The Dead Zone." Annual Review of Ecological Systems 33:235-263.

Raines, B. 2010. Whale sharks unable to avoid oil. *Mobile Press-Register*. Internet website: http://webcache.googleusercontent.com/search?q=cache:hyBVTTjMhakJ:blog.al.com/live/2010/06/whale_sharks_unable_to_avoid_o.html+Whale+Sharks+unable+to+avoid+oil&cd=1&hl=en&ct=clnk&gl=us. Accessed June 30, 2010.

Ramseur, J.L. 2010. Oil spill in U.S. coastal waters: Background, governance, and issues for Congress. Congressional Research Service. Report for Congress 7-57, RL33705. April 30, 2010.

Randall, M. 2008. Identification and characterization of critically essential winter habitat of juvenile Gulf sturgeon in the Apalachicola River, Florida. Final report to the U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 12 pp.

Rappole, J.H. 2006. A guide to the birds of the southeastern states: Florida, Georgia, Alabama, and Mississippi. University Press of Florida, Gainesville.

Rasmussen, E. 2008. Distance to the horizon, calculator. Erick's Blog. Internet website. http://www.erik-rasmussen.com/blog/2008/03/25/distance-to-the-horizon/. Posted March 25, 2008. Accessed December 30, 2010.

Ravishankara, A.R. and J. Goldman. 2010. Air chemistry in the Gulf of Mexico oil spill area, NOAA WP-3D Airborne Chemical Laboratory Flights of 8 and 10 June 2010. Internet website: http://www.esrl.noaa.gov/csd/tropchem/2010gulf/NOAA_P3_Gulf_Mission_Report_final.pdf.

Ray, J.P. 1998. Findings of the Offshore Operators Committee produced water bioaccumulation study. In: SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production. June 7-10, 1998. Caracas, Venezuela. Society of Petroleum Engineers, Inc.

Redden, J. 2009. Port Fourchon thrives despite the economy. Offshore Magazine. March 1, 2009. Internet website: http://www.offshore-mag.com/index/article-display/357201/articles/offshore/supplements/port-of-fourchon/articles/port-fourchon-thrives-despite-the-economy.html. Accessed December 3, 2010.

Reed, D.H. and K.R. Traylor-Holzer. 2006. Revised population viability analysis III for the Alabama beach mouse (*Peromyscus polionotus ammobates*). Report to the U.S. Dept. of the Interior, Fish and Wildlife Service. June 2006. 24 pp.

Regg, J.B., S. Atkins, B. Hauser, J. Hennessey, B. Kruse, J. Lowenhaupt, B. Smith, and A. White. 2000. Deepwater development: A reference document for the deepwater environmental assessment, Gulf of Mexico OCS (1998 through 2007). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2000-015. 94 pp.

Reible, D. 2010. After the oil is no longer leaking. The University of Texas, Austin. Environ. Sci. Technol. 44(15):5685–5686.

Reimer, A.A. 1975. Effects of crude oil on corals. Marine Pollution Bulletin 6(3):39-43.

RestoreTheGulf.gov. 2010a. Operations and ongoing response—July 06, 2010. Internet website: http://www.restorethegulf.gov/release/2010/07/06/operations-and-ongoing-response-july-06-2010. Accessed July 9, 2010.

RestoreTheGulf.gov. 2010b. Update: Rear Admiral Landry approves top kill procedure. Internet website: http://www.restorethegulf.gov/release/2010/05/26/update-rear-admiral-landry-approves-top-kill-procedure. Accessed October 5, 2010.

RestoreTheGulf.gov. 2010c. Consolidated Fish and Wildlife collection report—Nov. 2, 2010. Internet website: http://www.restorethegulf.gov/release/2010/11/02/consolidated-fish-and-wildlife-collection-report-nov-2-2010. Accessed February 13, 2010.

RestoreTheGulf.gov. 2010d. Unified Area Command weekly update—October 27, 2010. Internet website: http://www.restorethegulf.gov/release/2010/10/27/unified-area-command-weekly-update. Accessed. December 7, 2010.

RestoreTheGulf.gov. 2010e. The ongoing administration wide response to the *Deepwater Horizon* BP spill—August 6, 2010. Internet website: http://www.restorethegulf.gov/release/2010/08/06/ongoing-administration-wide-response-deepwater-bp-oil-spill. Accessed December 7, 2010.

RestoreTheGulf.gov. 2010f. *Deepwater Horizon* response consolidated fish and wildlife collection report: October 14, 2010. 1 p. Internet website: http://www.restorethegulf.gov/sites/default/files/documents/pdf/Consolidated%20Wildlife%20Table%20101410.pdf. Accessed January 20, 2011.

Reynolds, C.R. 1993. Gulf sturgeon sightings, historic and recent—a summary of public responses. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 40 pp.

Rezak, R. and T.J. Bright. 1979. Northwestern Gulf of Mexico topographic features study. Executive summary of the final report. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, Louisiana. Study no. 1979-14.

Rezak, R. and T.J. Bright. 1981. Northern Gulf of Mexico topographic features study: Final report to the U.S. Dept. of the Interior, Bureau of Land Management, Contract No. AA551-CT8-35. 5 vols.

Rezak, R., T.J. Bright, and D.W. McGrail. 1983. Reefs and banks of the northwestern Gulf of Mexico: Their geological, biological, and physical dynamics. Final Technical Report No. 83-1-T.

Rezak, R., T.J. Bright, and D.W. McGrail. 1985. Reefs and banks of the northwestern Gulf of Mexico: Their geological, biological, and physical dynamics. New York, NY: Wiley and Sons. 259 pp.

Rezak, R., S.R. Gittings, and T.J. Bright. 1990. Biotic assemblages and ecological controls on reefs and banks of the northwest Gulf of Mexico. American Zoologist 30:23-35.

Rhodes, D.C. 1974. Organism-sediment relations on the muddy sea floor. Oceanography and Marine Biology: An Annual Review 12:263-300.

Rhodes, D.C. and J.D. Germano. 1982. Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote ecological monitoring of the seafloor (Remots™ System). Marine Ecology Progress Series 8:115-128.

Rhodes, R.C., J.D. Thompson, and A.J. Wallcraft. 1989. Buoys-calibrated winds over the Gulf of Mexico. J. Atmos. and Ocean. Technology. 6(4):608-623.

Rice, S.A. and C.L. Hunter. 1992. Effects of suspended sediment and burial on Scleractinian corals from west central Florida patch reefs. Bulletin of Marine Science 51(3):429-442.

Richards, W.J. 1990. List of the fishes in the western central Atlantic and the status of early life history stage information. NOAA Technical Memorandum NMFS-SEFC-267. 88 pp.

Richardson, W.J., C.R. Greene, C.I. Mame, and D.H. Thomson. 1995. Marine mammals and noise. San Diego, CA: Academic Press Inc.

Richmond, E.A. 1962. The fauna and flora of Horn Island, Mississippi. Gulf Research Reports 1(2):59-106.

Ridgway, S.H. and D. Carder. 2001. Assessing hearing and sound production in cetacean species not available for behavioral audiograms: Experience with *Physeter*, *Kogia*, and *Eschrichtius*. Aquatic Mammals 27:267-276.

Rigzone. 2010. Rig report: Offshore rig fleet by region. Internet website: http://www.rigzone.com/data/. Accessed December 20, 2010.

Rinkevich, B. and Y. Loya. 1977. Harmful effects of chronic oil pollution on a Red Sea Scleractinian coral population. In: Taylor, D.L., ed. Proceedings, Third International Coral Reef Symposium. Volume 2: Geology. Miami, FL. May, 1977. Pp. 585-591.

Rinkevich, B. and Y. Loya. 1983. Response of zooxanthellae photosynthesis to low concentrations of petroleum hydrocarbons. Bulletin of the Institute of Oceanography and Fisheries 109-115.

Robbart, M.L., R.B. Aronson, K.J.P. Deslarzes, W.F. Precht, L. Duncan, B. Zimmer, and T. DeMunda. 2009. Post-hurricane assessment of sensitive habitats of the Flower Garden Banks vicinity. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-032. 160 pp.

Roberts, H.H. and T.W. Neurauter. 1990. Direct observations of a large active mud vent on the Louisiana continental slope. Association of Petroleum Geologists Bulletin 74:1508.

Roberts, H.H., P. Aharon, R. Carney, J. Larkin, and R. Sassen. 1990. Sea floor responses to hydrocarbon seeps, Louisiana continental slope. Geo-Marine Letter 10(4):232-243.

Robydek, A. and M. Nunley. 2008. Determining marine movement and behavior of Gulf sturgeon in the Gulf sturgeon critical habitat of the Eglin Gulf Testing and Training Range (EGTTR) and Santa Rosa Island (SRI) complex. Science Applications International Corporation. Eglin Air Force Base Natural Resources Section. DOD Legacy Resource Management Program.

Robydek, A. and M. Nunley. 2010. Determining marine movement and behavior of Gulf sturgeon in the Gulf of Mexico critical habitat of the Eglin Gulf Testing and Training Range (EGTTR) and Santa Rosa Island Complex. Presentation: 2010 Gulf Sturgeon Workshop meeting at Louisiana State University, Baton Rouge, LA.

Rocke, T.E., T.M. Yuill, and R.D. Hinsdill. 1984. Oil and related toxicant effects on mallard immune defenses. Environmental Research 33:343-352.

Rogers. C.S. 1990. Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series 62:185-202.

Rogers, C.S. and V.H. Garrison. 2001. Ten years after the crime: Lasting effects of damage from a cruise ship anchor on a coral reef in St. John, U.S. Virgin Islands. Bulletin of Marine Science 69(2):793-803.

Rogillio, H.E. 2007. Personal communication. Information describing the latest unpublished sturgeon population estimates for Gulf sturgeon in the Pearl River. Louisiana Dept. of Wildlife and Fisheries. January 2007.

Rogillio, H.E., R.T. Ruth, E.H. Behrens, C.N. Doolittle, W.J. Granger, and J.P. Kirk. 2007. Gulf sturgeon movements in the Pearl River drainage and the Mississippi Sound. North American Journal of Fisheries Management 27:89-95.

Romanov, A.A. and N.N. Sheveleva. 1993. Disrtuption of gonadogenesis in Caspian sturgeons. J. Ichthyol. 33:127-133.

Rooker, J.R., S.A. Holt, M.A. Soto, and G.J. Holt. 1998. Postsettlement patterns of habitat use by Sciaenid fishes in subtropical seagrass meadows. Estuaries 21(2):318-327.

Roosenburg, W.M. 1994. Nesting habitat requirements of the diamondback terrapin: A geographic comparison. Wetland Journal 6(2):8-11.

Roosenburg, W.M., K.L. Haley, and S. McGuire. 1999. Habitat selection and movements of the diamondback terrapin, *Malaclemys terrapin*, in a Maryland estuary. Chelonian Conservation and Biology 3:425-429.

Rosman, I., G.S. Boland, and J.S. Baker. 1987. Epifaunal aggregations of Vesicomyidae on the continental slope off Louisiana. Deep-Sea Res. 34:1811-1820.

Ross, S.T., R.J. Heise, W.T. Slack, and M. Dugo. 2001. Habitat requirements of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the northern Gulf of Mexico. University of Southern Mississippi, Dept. of Biological Sciences and Mississippi Museum of Natural Science. Funded by the Shell Marine Habitat Program, National Fish and Wildlife Foundation. 26 pp.

Ross, S.T., W.T. Slack, R.J. Heise, M.A. Dugo, H. Rogillio, B.R. Bowen, P. Mickle, and R.W. Heard. 2009. Estuarine and coastal habitat use of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) in the north-central Gulf of Mexico. Estuaries and Coasts 32:360-374.

Roth, A.F. and D.M. Baltz. 2009. Short-term effects of an oil spill on marsh-edge fishes and decapod crustaceans. Estuaries and Coasts 32:565-572.

Rotkin-Ellman, M., K.M. Navarro, and G.M. Solomon. 2010. Gulf oil spill air quality monitoring: Lessons learned to improve emergency response. Environ. Sci. Technol. 44(22):8365–8366.

Rowe, G.T. and M.C. Kennicutt II. 2001. Deepwater program: Northern Gulf of Mexico continental slope benthic habitat and ecology. Year I: Interim report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-091. 166 pp.

Rowe, G.T. and M.C. Kennicutt II, eds. 2009. Northern Gulf of Mexico continental slope habitats and benthic ecology study: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-039. 456 pp.

Rowe, G. and D.W. Menzel. 1971. Quantitative benthic samples from the deep Gulf of Mexico with some comments on the measurements of deep-sea biomass. Bulletin of Marine Science 21(2):556-566.

Roy, K.J. and S.V. Smith. 1971. Sedimentation and coral reef development in turbid water: Fanning Lagoon. Pacific Science 25:234-248.

Rozas, L.P. 1992. Comparison of nekton habitats associated with pipeline canals and natural channels in Louisiana salt marshes. Wetlands 12(2):136-146.

Rozas, L.P. and W.E. Odum. 1988. Occupation of submerged aquatic vegetation by fishes: Testing the roles of food and refuge. Oecologia 77:101-106.

Rucker, J.B. and J.O. Snowden. 1989. Relict progradational beach ridge complex on Cat Island in Mississippi Sound. Trans. Gulf Coast Assoc. of Geol. Soc. 39:531-539.

Runcie, J., C. Macinnis-Ng, and P. Ralph. 2004. The toxic effects of petrochemical on seagrasses. Literature review. For Australian Maritime Safety Authority, Institute for Water and Environmental Resource Management, Sydney, Australia. 20 pp. Internet website: http://www.amsa.gov.au/marine_environment_protection/national_plan/Contingency_Plans_and_Management/Research_Development_and_Technology/Toxic_Effects_Seagrasses.pdf.

Russell, R.W. 2005. Interactions between migrating birds and offshore oil and gas platforms in the northern Gulf of Mexico: Final report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 327 pp.

Russo, M. 1992. Variations in late archaic subsistence and settlement patterning in peninsular Florida. In: Jeter, M., ed. Southeastern Archaeological Conference: Abstracts of the forty-ninth annual meeting, Little Rock, AR.

Rützler, K. and W. Sterrer. 1970. Oil pollution damage observed in tropical communities along the Atlantic seaboard of Panama. BioScience 20(4):222-224.

Ryan, P.G. 1988. Effects of ingested plastic on seabird feeding: Evidence from chickens. Marine Pollution Bulletin 19(3):125-128.

Ryan, P.G. 1990. The effects of ingested plastic and other marine debris on seabirds. In: Shomura, R.S. and M.L. Godfrey, eds. Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, HI. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NOAA-TM-NMFS-SWFSC-154. Pp. 623-634.

S.L. Ross Environmental Research Ltd.. 1997. Fate and behavior of deepwater subsea oil well blowouts in the Gulf of Mexico. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. 27 pp. Internet website: http://www.boemre.gov/tarprojects/287/287AA.PDF.

S.L. Ross Environmental Research Ltd. 2000. Technology assessment of the use of dispersants on spills from drilling and production facilities in the Gulf of Mexico outer continental shelf. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, Engineering and Research Branch, Herndon, VA. 19 pp. Internet website: http://www.boemre.gov/tarprojects/349/349AB.pdf.

Sadiq, M. and J.C. McCain. 1993. The Gulf War aftermath: An environmental tragedy. Dordrecht: Kluwer Academic Publishers.

Sager, W. 1997. Geophysical detection and characterization of seep community sites. In: MacDonald, I.R., ed. 1998. Stability and change in Gulf of Mexico chemosynthetic communities: Interim report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0034. Pp. 49-60.

Sager, W.W., W.W. Schroeder, J.S. Laswell, K.S. Davis, R. Rezak, and S.R. Gittings. 1992. Mississippi-Alabama outer continental shelf topographic features formed during the late Pleistocene-Holocene transgression. Geo-Marine Letters 12:41-48.

Salmon, J., D. Henningsen, and T. McAlpin. 1982. Dune restoration and revegetation manual. Florida Sea Grant College. Report No. 48, September. 49 pp.

Sammarco, P.W., A.D. Atchison, D.A. Brazeau, G.S. Boland, and D.F. Gleason. 2004. Expansion of coral communities within the northern Gulf of Mexico via offshore oil and gas platforms. Marine Ecology Progress Series 280:129-143.

Sanders, H.L., J.F. Grassle, G.R. Hamson, L.S. Morse, S. Garner-Price, and C.C. Jones. 1980. Anatomy of an oil spill: Long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. Journal of Marine Research 38:265-380.

Santos, M.F.L., P.C. Lana, J. Silva, J.G. Fachel, and F.H. Pulgati. 2009. Effects of non-aqueous fluids cuttings discharge from exploratory drilling activities on the deep-sea macrobenthic communities. Deep-Sea Research II 56:32-40.

Sapp, C.D. and J. Emplaincourt. 1975. Physiographic regions of Alabama. Geological Survey of Alabama, Tuscaloosa, Alabama. Alabama Geological Survey special map 168.

Sargent, F.J., T.J. Leary, D.W. Crewz, and C.R. Kruer. 1995. Scarring of Florida's seagrasses: Assessment and management options. FRMI TR-1, Florida Marine Research Institute, St. Petersburg, FL. 37 pp. + app.

Sassen, R. 1998. Origins of hydrocarbons and community stability. In: MacDonald, I.R., ed. Stability and change in Gulf of Mexico chemosynthetic communities: Interim report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-00034. Pp. 71-76.

Sassen, R., J.M. Brooks, M.C. Kennicutt II, I.R. MacDonald, and N.L. Guinasso, Jr. 1993a. How oil seeps, discoveries relate in deepwater Gulf of Mexico. Oil and Gas Journal 91(16):64-69.

Sassen, R., H.H. Roberts, P. Aharon, J. Larkin, E.W. Chinn, and R. Carney. 1993b. Chemosynthetic bacterial mats at cold hydrocarbon seeps, Gulf of Mexico continental slope. Organic Geochemistry 20(1):77-89.

Sathiakumar, N. 2010. Short-term physical effects: Oil spills. Presentation, School of Public Health, University of Alabama at Birmingham. http://www.iom.edu/~/media/Files/Activity%20Files/PublicHealth/OilSpillHealth/NaliniSathiakumar-6-22-1110am.pdf.

Saunders, J., A. Thurman, and R.T. Saucier. 1992. Preceramic(?) mound complexes in northeastern Louisiana. In: Jeter, M.D., ed. Southeastern Archaeological Conference: Abstracts of the Forty-Ninth Annual Meeting, Little Rock, AR.

Sayre, A. 2010. Forecast: Louisiana will have slow job growth. Internet website: http://www.businessweek.com/ap/financialnews/D9IMCA800.htm. Accessed December 12, 2010.

Scaife, W.W., R.E. Turner, and R. Costanza. 1983. Coastal Louisiana recent land loss and canals impacts. Environmental Management 7(5):433-442.

Schales, S. and D. Soileau. 2001. Personal communication with Samuel Holder: Shell Key, Point au Fer ,and their surrounding shell reefs, June 15. Both gentlemen were employed by the Louisiana Dept. of Wildlife and Fisheries at the time.

Schaum, J., M. Cohen, S. Perry, R. Artz, R. Draxler, J.B. Frithsen, D. Heist, M. Lorber, and L. Phillips. 2010. Screening level assessment of risks due to dioxin emissions from burning oil from the BP *Deepwater Horizon* Gulf of Mexico spill. Environ. Sci. Technol. 44(24):9383–9389. Internet website: http://www.epa.gov/research/dioxin/docs/OilScreen25.pdf.

Schiro, A.J., D. Fertl, L.P. May, G.T. Regan, and A. Amos. 1998. West Indian manatee (*Trichechus manatus*) occurrence in U.S. waters west of Florida. Presentation at the World Marine Mammal Conference, 20-24 January, Monaco.

Schlager, W. 1981. The paradox of drowned reefs and carbonate platforms. Geological Society of America Bulletin 92(4):197-211. Internet website: http://bulletin.geoscienceworld.org/cgi/content/abstract/92/4/197.

Schmahl, G.P. and E.L. Hickerson. 2006. McGrail Bank, a deep tropical coral reef community in the northwestern Gulf of Mexico. In: Proceedings of 10th International Coral Reef Symposium. June 28-July 2, 2006, Okinawa, Japan.

Schmahl, G.P., E.L.Hickerson, D.C.Weaver, and J.V.Gardner. 2003. High-resolution multibeam mapping of topographic features in the northwestern Gulf of Mexico. In: Proceedings of the U.S. Hydro Conference, March 24-27, 2003, Biloxi, MS.

Schmidt, K. 2010a. Despite fears following spill, local jobless rate holds steady. Internet website: http://www.reefrelieffounders.com/drilling/2010/09/25/daily-comet-despite-fears-following-spill-local-jobless-rate-holds-steady/. Accessed December 12, 2010.

Schmidt, K. 2010b. Still no employment impact from spill, drilling uncertainty. Internet website: http://www.dailycomet.com/article/20101028/ARTICLES/101029226. Accessed December 10, 2010.

Schofield, P.J. 2009. Geographic extent and chronology of the invasion of the non-native lionfish (*Pterois volitans* [Linneaus 1758] and *P. miles* [Bennett 1828]) in the western North Atlantic and Caribbean Sea. Aquatic Invasions 4(3):473-479.

Scholz, D.K., J.H. Kucklick, R.G. Pond, A.H. Walker, A. Bostrom, and P. Fischbeck. 1999. Fate of spilled oil in marine waters: Where does it go? What does it do? How do dispersants affect it? An information booklet for decision-makers. American Petroleum Institute Publication Number 4691, 43 pp. Internet website: http://www.cleancaribbean.org/ccc_doc/pdf/API_Fate_of_Spilled_Oil.pdf.

Schroeder, W.W. 2000. Shelf hard bottom habitats. In: Schroeder, W.W. and C.F. Wood, eds. Physical/Biological Oceanographic Integration Workshop for DeSoto Canyon and Adjacent Shelf, October 19-21, 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-074. Pp. 67-71.

Schroeder, W.W. 2002. Observations of *Lophelia pertusa* and the surficial geology at a deep-water site in the northeastern Gulf of Mexico. Hydrobiologia 471:29-33.

Schroeder, D.M. and M.S. Love. 2004. Ecological and political issues surrounding decommissioning of offshore oil facilities in the southern California Bight. Ocean and Coastal Management 47:21-48.

Schroeder, W.W., A.W. Shultz, and J.J. Dindo. 1988. Inner-shelf hardbottom areas, northeastern Gulf of Mexico. Trans. Gulf Coast Assoc. Geol. Soc. 38:535-541.

Schroeder, W.W., M.R. Dardeau, J.J. Dindo, P. Fleisher, K.L. Heck Jr., and A.W. Shultz. 1989. Geophysical and biological aspects of hardbottom environments on the MAFLA shelf, northern Gulf of Mexico. Proceedings Oceans ’88 Conference. Pp. 17-21.

Schummer, M.L. and W.R. Eddleman. 2003. Effects of disturbance on activity and energy budgets of migrating waterbirds in south-central Oklahoma. Journal of Wildlife Management 67:789-795.

Schwartz, F.J. 1988. Aggregations of young hatchling loggerhead sea turtles in the Sargassum off North Carolina. Marine Turtle Newsletter 42: 9-10

Schwartz, A. 2010. China beats U.S. to first offshore wind farm. Internet website: http://www.fastcompany.com/1687492/china-beats-us-to-first-offshore-wind-farm#. Posted September 8, 2010. Accessed March 23, 2011.

Scollan, D and F.M. Parauka. 2008. Documentation of Gulf sturgeon spawning in the Apalachicola River, Florida. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 26 pp.

Scott-Denton, E. 2009. Personal communication. Incidental seabird bycatch in fisheries in the Gulf of Mexico. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Seni, S.J. and M.P.A. Jackson. 1983. Evolution of salt structures, east Texas diapir province, Part 2: Patterns and rates of halokinesis. The American Association of Petroleum Geologists Bulletin 67(8):1245-1274.

Shaffer, G.P., J.W. Day, S. Mack, G.P. Kemp, I. van Heerden, M.A. Poirrier, K.A.Westphal, D. FitzGerald, A. Milanes, C.A. Morris, R. Bea, and P.S. Penland. 2009. The MRGO navigation project: A massive human-induced environmental, economic, and storm disaster. Journal of Coastal Research 54:206-224.

Shafir, S., J. Van Rijn, and B. Rinkevich. 2007. Short and long term toxicity of crude oil and oil dispersants to two representative coral species. Environmental Science and Technology 41:5571-5574.

Sharp, B.E. 1996. Post-release survival of oiled, cleaned seabirds in North America. Ibis 138:222-228.

Sharp, J.M. and S.G. Appan. 1982. The cumulative ecological effects of normal offshore petroleum operations contrasted with those resulting from continental shelf oil spills. Philosophical Transactions of the Royal Society of London. B: Biological Sciences 297:309-322.

Sheavly, S.B. 2007. National marine debris monitoring program: Final program report, data analysis and summary. Prepared for the U.S. Environmental Protection Agency by Ocean Conservancy. Grant Number X83053401-02. 76 pp.

Shepherd, J.M. and T. Knutson. 2007. The current debate on the linkage between global warming and hurricanes. Geography Compass 1(1):1-24.

Shigenaka, G. 2001. Toxicity of oil to reef-building corals: A spill response perspective. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Seattle, WA. NOAA Technical Memorandum NOS OR&R 8. 95 pp. Internet website: http://response.restoration.noaa.gov/book_shelf/1_coral_tox.pdf.

Shinn, E.A., J.H. Hudson, D.M. Robbin, and C.K. Lee. 1980. Drilling mud plumes from offshore drilling operations: Implications for coral survival. The R&D Program for OCS Oil and Gas Operations. U.S. Dept. of the Interior, Geological Survey, Fisher Island Station, Miami Beach, FL.

Shinn, E.A., B.H. Lidz, and C.D. Reich. 1993. Habitat impacts of offshore drilling: Eastern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 93-0021. 73 pp.

Shipp, R.L. and T.L. Hopkins. 1978. Physical and biological observations of the northern rim of the DeSoto Canyon made from a research submersible. N.E. Gulf Sci. 2(2):113-121.

Shirayama, Y. and H. Thornton. 2005. Effect of increased atmospheric CO_2 on shallow water marine benthos. Journal of Geophysical Research 110(C09) S09, doi:10.1029/2004JC002561.

Short, F.T., R.G. Coles, and C. Pergent-Martini. 2001. Global seagrass distribution. In: Short, F.T. and R.G. Coles, eds. 2001. Global seagrass research methods. Amsterdam, The Netherlands: Elsevier Science B.V. Pp 5-6, 20.

Sibley, D.A. 2000. The Sibley guide to birds. National Audubon Society, Knopf, NY. 544 pp.

Singh, T. 2010. China starts construction on world's biggest offshore wind farm. Internet website: http://inhabitat.com/china-starts-construction-on-worlds-biggest-offshore-wind-farm/. Posted October 25, 2010. Accessed March 24, 2011.

Skagen, S.K. and F.L. Knopf. 1993. Toward conservation of midcontinental shorebird migrations. Conservation Biology 7:533-541.

Skagen, S.K., D.A. Granfors, and C.P. Melcher. 2008. On determining the significance of ephemeral continental wetlands to North American migratory shorebirds. Auk 125:20-29.

Slack, T. 2008. Personal communication. Information concerning the critical habitat and damage assessments of the Gulf sturgeon. Representing the Mississippi State Museum of Natural Science, Jackson, MS. Meeting held in New Orleans, LA, on January 27, 2008.

Smith, M.F., ed. 1984. Ecological characterization atlas of coastal Alabama: Map narrative. U.S. Dept. of the Interior, Fish and Wildlife Service FWS/OBS-82/46 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 84-0052. 189 pp.

Smith, R.C., J.R. Bratten, J. Cozzi, and K. Plasket. n.d. The Emanuel Point ship archaeological investigations 1997-1998. Archaeology Institute, University of West Florida, Pensacola, FL. Report of Investigations No. 68.

Smultea, M.A. and B. Würsig. 1995. Behavioral reactions of bottlenose dolphins to the *Mega Borg* oil spill, Gulf of Mexico 1990. Aquatic Mammals 21:171-181.

Snedden, G.A. In preparation. Forcing functions governing salt transport processes in coastal navigation canals and connectivity to surrounding wetland landscapes in south Louisiana using Houma navigation canal as a surrogate. U.S. Dept. of the Interior, Geological Survey, National Wetlands Research Center, Baton Rouge, LA.

South Alabama Regional Planning Commission. 2001. Fort Morgan Peninsula resource assessment. Alabama Dept. of Conservation and Natural Resources, Mobile, AL. 26 pp.

South Atlantic Fishery Management Council. 2002. Fishery management plan for pelagic Sargassum habitat of the South Atlantic Region, including a final environmental impact statement, initial regulatory flexibility analysis, regulatory impact review, & social impact assessment/fishery impact statement: Second revised final. South Atlantic Fishery Management Council, Charleston, SC.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Southwest Research Institute. 1981. Ecological investigations of petroleum production platforms in the central Gulf of Mexico. Submitted to the U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Contract no. AA551-CT8-17.

Spalding, E.A. and M.W. Hester. 2007. Effects of hydrology and salinity on oligohaline plant species productivity: Implications of relative sea-level rise. Estuaries and Coasts 30(2):214-225.

Spies, R.B., J.S. Felton, and L. Dillard. 1982. Hepatic mixed-function oxidases in California flatfishes are increased in contaminated environments and by oil and PCB ingestion. Marine Biology 70:117-127.

Sports Fishing Institute. 1989. Marine fisheries by catch issues. Sports Fishing Institute, Washington, DC. Bulletin No. 405. 6 pp.

St. Aubin, D.J. and V. Lounsbury. 1990. Chapter 11. Oil effects on manatees: Evaluating the risks. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc. Pp. 241-251.

Stabile, J., J.R. Waldman, F. Parauka, and I. Wirgin. 1996. Stock structure and homing fidelity in Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi*) based on restriction fragment length polymorphism and sequence analyses of mitochondrial DNA. Genetics 144:767-775.

Stadelman, W.J. 1958. The effects of sounds of varying intensity on hatchability of chicken eggs. Poultry Science 37:166-169.

State of Alabama. n.d. Oil & gas industry. Geological Survey of Alabama and State Oil and Gas Board of Alabama. Internet website: http://www.gsa.state.al.us/documents/oginfo/og_industry.pdf. Accessed February 17, 2011.

State of Florida. Division of Historic Resources. 2010. The Emanuel Point shipwreck. Internet website: http://www.flheritage.com/archaeology/projects/shipwrecks/emanuelpoint/. Accessed August 11, 2010.

State of Louisiana. 2007. Integrated ecosystem restoration and hurricane protection: Louisiana's comprehensive master plan for a sustainable coast. Coastal Protection and Restoration Authority of Louisiana, Baton Rouge, LA. Internet website: http://www.lacpra.org/index.cfm?md=pagebuilder&tmp=home&nid=24&pnid=0&pid=28&fmid=0&catid=0&elid=0. Accessed April 7, 2011.

State of Louisiana. 2010. Election 2010: Constitutional amendments results. Internet website: http://www.legis.state.la.us/election2010/amendments.htm. Accessed January 23, 2011.

State University System of Florida Institute of Oceanography (SUSIO). 1977. Baseline monitoring studies: Mississippi, Alabama, Florida outer continental shelf, 1975-1976. Volume I: Executive summary. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans, LA. Contract No. 08550-CT5-30. 55 pp.

Stehn, T. 2007. Personal communication. Captive and wild whooping crane population sizes in 2007. Wildlife Biologist, U.S. Dept. of the Interior, Fish and Wildlife Service, Aransas National Wildlife Refuge, Texas.

Steidl, R.J. and B.F. Powell. 2006. Assessing the effects of human activities on wildlife. George Wright Forum 23:50-58.

Stephens, B.P. 2009. Basement controls on subsurface geologic patterns and coastal geomorphology across the northern Gulf of Mexico: Implications for subsidence studies and coastal restoration. Transactions Gulf Coast Association of Geological Societies 59:729-751. Internet website: http://www.searchanddiscovery.net/abstracts/html/2009/gcags/abstracts/stephens.htm.

Stephens, B.P. 2010a. Basement controls on subsurface geologic patterns and near-surface geology across the northern Gulf of Mexico: A deeper perspective on coastal Louisiana. American Association of Petroleum Geologists, Annual Conference and Exhibition, April 11-14, 2010, New Orleans, LA. Search and Discovery Article #30129. Internet website: http://www.searchanddiscovery.net/documents/2010/30129stephens/ndx_stephens.pdf.

Stephens, B.P. 2010b. Basement controls on subsurface geologic patterns and coastal geomorphology across the northern Gulf of Mexico: Implications for subsidence studies and coastal restoration. Adapted from the presentation given to New Orleans Geological Society, July 14, 2010.

Stephenson, R. 1997. Effects of oil and other surface-active organic pollutants on aquatic birds. Environmental Conservation 24:121-129.

Stephenson, R. and C.A. Andrews. 1997. The effect of water surface tension on feather wetability in aquatic birds. Canadian Journal of Zoology 74:288-294.

Steyer, G.D., B.C. Perez, S.P. Piazza, and G. Suir. 2007. Potential consequences of saltwater intrusion associated with Hurricanes Katrina and Rita. In: Farris, G.S., G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins, and D.L. Lavoie, eds. Science and the storms—the USGS response to the hurricanes of 2005. U.S. Dept. of the Interior, Geological Survey. Geological Survey Circular 1306. Pp. 137-146. Internet website: http://pubs.usgs.gov/circ/1306/. Accessed April 17, 2011.

Steyer, G.D., C. Sasser, E. Evers, E. Swenson, G. Suir, and S. Sapkota. 2008. Influence of the Houma navigation canal on salinity patterns and landscape configuration in coastal Louisiana: An interagency collaboration: U.S. Dept. of the Interior, Geological Survey. Geological Survey Open-File Report 2008-1127. 190 pp.

Steyn, P. 2010. *Exxon Valdez* oil spill. Answers.com. Internet website: http://www.answers.com/topic/exxon-valdez-oil-spill. Accessed November 23, 2010.

Stone, R.B. 1974. A brief history of artificial reef activities in the United States. In: Proceedings: Artificial Reef Conference, Houston, TX. Pp. 24-27.

Stone, G.W. 2001. Wave climate and bottom boundary layer dynamics with implications for offshore sand mining and barrier island replenishment in south-central Louisiana. U.S. Dept. of the Interior,

Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-053. 90 pp.

Stone, R.B., W. Pratt, R.O. Parker, and G. Davis. 1979. A comparison of fish populations on an artificial and natural reef in the Florida Keys. Mar. Fish. Rev. 41(9):1-24.

Stoner, A.W. 1983. Pelagic Sargassum: Evidence for a major decrease in biomass. Deep-Sea Research Part A. Oceanographic Research Papers 30(4):469-474.

Sturges. W., E. Chassignet, and T. Ezer. 2004. Strong mid-depth currents and a deep cyclonic gyre in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS-2004-040. 89 pp.

Sturm, D.J., J. Stout, and T. Thibaut. 2007. Statewide summary for Alabama. In. Handley, D.A., D. Altsman, and R. DeMay, eds. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. Scientific Investigations Report 2006-5287. U.S. Environmental Protection Agency 855-R-04-003. Pp. 87-97. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed May 20, 2011.

Stutzenbaker, C.D. and M.W. Weller. 1989. The Texas coast. In: Smith, L.M., R.L. Pederson, and R.K. Kaminski, eds. Habitat management for migrating and wintering waterfowl in North America. Lubbock, TX: Texas Tech. University Press. Pp. 385-405.

Suchanek, T.H. 1993. Oil impacts on marine invertebrate populations and communities. American Zoologist 33:510-523.

Sulak, K. 1997. Personal communication. Conversations regarding recent information and research concerning the Gulf sturgeon at the Seventeenth Annual Information Transfer Meeting held in December 1997 in New Orleans, LA.

Sulak, K.J. and J.P. Clugston. 1998. Early life history stages of Gulf sturgeon in the Suwannee River, Florida. Transactions of American Fisheries Society 127:758-771

Sulak, K.J. and J.P. Clugston. 1999. Recent advance in life history of Gulf of Mexico sturgeon, *Acipenser oxyrinchus desotoi*, in the Suwannee River, Florida, USA: A synopsis. Journal of Applied Ichthyology 15:116-128.

Sulak, K.J., M.T. Randall, R.E. Edwards, T.M. Summers, K.E. Luke, W.T. Smith, A.D. Norem, W.M. Harden, R.H. Lukens, F. Parauka; S. Bolden, and R. Lehnert. 2009. Defining winter trophic habitat of juvenile Gulf sturgeon in the Suwannee and Apalachicola rivermouth estuaries, acoustic telemetry investigations. Journal of Applied Ichthyology, special volume: Proceedings of the Sustainable Sturgeon Symposium, American Fisheries Society, Ottawa, Canada, August 2008.

Swann, L. n.d. Alabama and Mississippi estuarine habitats status and trends. Mississippi-Alabama Sea Grant Consortium and Auburn University. Internet website: http://www.masgc.org/ppt/AL_MS_Habitat_Status_Trends_files/frame.htm. Accessed October 13, 2010.

Swanson, C., F.D. McCay, S. Subbayya, J. Rowe, P. Hall, and T. Isaji. 2003. Modeling dredging-induced suspended sediment and the environmental effects in Mt. Hope Bay and the Taunton River for the proposed Weaver's Cove Energy, LLC, Liquefied Natural Gas Import Terminal. Prepared by Applied Science Associates for Weaver's Cove Energy, LLC.

Swenson, E.M. and R.E. Turner. 1987. Spoil banks: Effects on a coastal marsh water-level regime. Estuarine Coastal Shelf Science 24:599-609.

Swift, T.L. and S.J. Hannon. 2010. Critical thresholds associated with habitat loss: A review of the concepts, evidence, and applications. Biological Reviews 85:35-53.

Swilling, W.R., Jr., M.C. Wooten, N.R. Holler, and W.J. Lynn. 1998. Population dynamics of Alabama beach mice (*Peromyscus polionotus ammobates*) following Hurricane Opal. Amer. Midland Nat. 140:287-298.

Systems Applications International, Sonoma Technology, Inc., Earth Tech, Alpine Geophysics, and A.T. Kearney. 1995. Gulf of Mexico air quality study: Final report. Volumes I-III. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0038, 95-0039, and 95-0040. 650, 214, and 190 pp., respectively.

Szaro, R.C., P.H. Albers, and N.C. Coon. 1978a. Petroleum: effects on mallard egg hatchability. Journal of Wildlife Management 42:404-406.

Szaro, R.C., M.P. Dieter, G.H. Heinz, and J.F. Ferrell. 1978b. Effects of chronic ingestion of south Louisiana crude oil on mallard ducklings. Environmental Research 17:426-436.

Tan, L., M. Belanger, and C. Wittnich. 2010. Revisiting the correlation between estimated seabird mortality and oil spill size. Journal of Marine Animals and Their Ecology 3(1):20-26.

Taylor, H.A., M.A. Rasheed, and R. Thomas. 2006. Port Curtis post oil spill seagrass assessment, Gladstone-2006. DPI&F Information Series QI06046 (DPI&F, Cairns). 19 pp. Internet website: http://www.seagrasswatch.org/Info_centre/Publications/pdf/meg/GladstonePostOilSpillReport2006_Final.pdf.

Teal, J.M. and R.W. Howarth. 1984. Oil spill studies: A review of ecological effects. Environmental Management 8:27-44.

Teal, J.M., J.W. Farrington, K.A. Burns, J.J. Stegeman, B.W. Tripp, B. Woodin, and C. Phinney. 1992. The West Falmouth oil spill after 20 years: Fate of fuel oil compounds and effects on animals. Marine Pollution Bulletin 24(12):607-614.

Teas, W.G. 1994. Marine turtle stranding trends, 1986-1993. In: Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar, comps. Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351. Pp. 293-295.

Telesnicki, G.J. and W.M. Goldberg. 1995. Effects of turbidity on the photosynthesis and respiration of two south Florida reef coral species. Bulletin of Marine Science 57(2):527-539.

Tenaglia, K.M., J.L. Van Zant, and M.C. Wooten. 2007. Genetic relatedness and spatial associations of jointly captured Alabama beach mice (*Peromyscus polionotus ammobates*). Journal of Mammalogy 88:580-588.

Teo, S.L.H, A. Boustany, H. Dewar, M.J.W. Stokesbury, K.C. Weng, S. Beemer, A.C. Seitz, C.J. Farwell, E.D. Prince, and B.A. Block. 2007a. Annual migrations, diving behavior, and thermal biology of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology 151:1-18.

Teo, S.L.H, A. Boustany, and B.A. Block. 2007b. Oceanographic preferences of Atlantic bluefin tuna, *Thunnus thynnus*, on their Gulf of Mexico breeding grounds. Marine Biology 152:1105-1119.

Terres, J.K. 1991. The Audubon Society encyclopedia of North American birds. New York, NY: Wing Books. 1,109 pp.

Teslik, L.H. and C. Menegatti. 2010. Oil spill will hurt U.S. economy, but not big enough to cause recession. *The Washington Post*. Internet website: http://www.washingtonpost.com/wp-dyn/content/article/2010/07/01/AR2010070105311_pf.html. Accessed July 3, 2010.

Tetrahedron, Inc. 1996. Reliability of blowout preventers tested under fourteen and seven days time interval. Study report prepared for the U.S. Dept. of the Interior, Minerals Management Service. TA&R Project 253. 33 pp. Internet website: http://www.boemre.gov/tarprojects/253/AA.PDF.

Texas Parks and Wildlife Department. 1990. Texas colonial waterbird census summary. Texas Parks and Wildlife Department and the Texas Colonial Waterbird Society, Special Administrative Report.

Texas Parks and Wildlife Department. 1999. Seagrass conservation plan for Texas. Texas Parks and Wildlife, Resource Protection Division, Austin, TX. 79 pp. Internet website: http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_bk_r0400_0041.pdf.

Thatcher, C.A., S.B. Hartley, and S.A. Wilson. 2011. Bank erosion of navigation canals in the western and central Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey, National Wetlands Resource Center, Open-File Report 2010-1017 and U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study BOEMRE 2010-039. 32 pp. + 2 apps. Internet website: http://pubs.usgs.gov/of/2010/1017_p/pdf/OF10-1017.pdf.

The Encyclopedia of Earth. 2008. Gulf of Mexico large marine ecosystem. Internet website: http://www.eoearth.org/article/Gulf_of_Mexico_large_marine_ecosystem?topic=49522. Updated December 28, 2010. Accessed January 11, 2011.

The Greater Lafourche Port Commission (TGLPC). 2010a. Map of waterfront property available at Port Fourchon. Internet website: http://www.portfourchon.com/site100-01/1001757/docs/2010_7_1_waterfront.pdf. Accessed December 2, 2010.

The Greater Lafourche Port Commission (TGLPC). 2010b. Map of non-waterfront property available at Port Fourchon. Internet website: http://www.portfourchon.com/site100-01/1001757/docs/2010_7_1_nonwaterfront.pdf. Accessed December 3, 2010.

The Greater Lafourche Port Commission (TGLPC). 2010c. Port Fourchon north expansion. Internet website: http://www.portfourchon.com/explore.cfm/northernexpansion/. Accessed December 3, 2010.

The Greater Lafourche Port Commission (TGLPC). 2010d. South Lafourche airport in "excellent condition:" Many improvements since Port Commission acquisition. Internet website: http://www.portfourchon.com/explore.cfm/20100222airptrev/. Accessed December 3, 2010.

The Heinz Center. 2010. Evaluation of erosion hazards. Prepared for the Federal Emergency Management Agency. Contract EMW-97-CO-0375. 205 pp.

The Knowland Group. 2010. The Knowland Group releases oil spill survey findings following Memorial Day. Internet website: http://www.hotelnewsresource.com/article46295.html. Accessed June 4, 2010.

The Louis Berger Group, Inc. 2004. OCS-related infrastructure in the Gulf of Mexico fact book. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-027. 249 pp.

The Louisiana Justice Institute. 2010. Briefing document: Impact of BP oil spill on African-American fisher communities in Louisiana. Internet website: http://www.louisianajusticeinstitute.org/files/all/docs/Briefing_Document_Vol_1-Issue_1.pdf. Accessed March 28, 2011.

The Oil Drum. 2009. USA Gulf of Mexico oil production forecast update. Internet website: http://www.theoildrum.com/node/5081. Posted February 9, 2009. Accessed January 4, 2011.

The White House. 2010. Establishing the Gulf Coast Ecosystem Restoration Task Force. Office of the Press Secretary, Executive Order, October 5, 2010. Internet website: http://www.whitehouse.gov/the-press-office/2010/10/05/executive-order-gulf-coast-ecosystem-restoration-task-force.

Thistle, D. 1981. Natural physical disturbances and communities of marine soft bottoms. Marine Ecology Progress Series 6:223-228.

Thompson, J.H. 1979. Effects of drilling mud on seven species of reef-building coral as measured in field and laboratory. Report to the U.S. Dept. of the Interior, Geological Survey from Texas A&M University, Department of Oceanography, College Station, TX. TA&R Project No. 20. Internet website: http://www.boemre.gov/tarprojects/020/20_aa.pdf.

Thompson, M.J., W.W. Schroeder, and N.W. Phillips. 1999. Ecology of live bottom habitats of the northeastern Gulf of Mexico: A community profile. U.S. Dept. of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0001 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 99-0004. x + 74 pp.

Thorhaug, A. 1988. Dispersed oil effects on mangroves, seagrasses, and corals in the wider Caribbean. Proceedings of the 6th International Coral Reef Symposium, Australia 2:337-339.

Thorhaug, A., J. Marcus, and F. Booker. 1986. Oil and dispersed oil on subtropical and tropical seagrasses in laboratory studies. Marine Pollution Bulletin 17:357-631.

Tiner, R.W. 1984. Wetlands of the United States: Current status and recent trends. U.S. Dept. of the Interior, Fish and Wildlife Service, Newton Corner, MA. vii + 59 pp.

Tkalich, P. and E.S. Chan. 2002. Vertical mixing of oil droplets by breaking waves. Marine Pollution Bulletin 44:1219-1229.

Tokotch, B. 2010. Oil and coral fact sheet. 3 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/Oil-CoralOnePage.pdf. Accessed December 6, 2010.

Tolbert, C.M. 1995. Oil and gas development and coastal income inequality: Case studies at the place level. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 94-0052. 75 pp.

Tolbert, C.M. and M. Sizer. 1996. U.S. commuting zones and labor market areas: 1990 update. U.S. Dept. of Agriculture, Economic Research Service, Rural Economy Division. Staff Paper No. AGES-9614.

Toll Road News. 2009. LA1 bridge to Gulf oil & gas is tolling. Internet website: http://tollroadsnews.com/node/4305. Accessed December 3, 2010.

Torres, J.L. 2001. Impacts of sedimentation on the growth rates of *Montastraea annularis* in southwest Puerto Rico. Bulletin of Marine Science 69(2):631-637.

Torres, R., M. Chiappone, F. Geraldes, Y. Rodriguez, and M. Vega. 2001. Sedimentation as an important environmental influence on Dominican Republic reefs. Bulletin of Marine Science 69(2):805-818.

Trapido, E.J. 2010. Health and the *Deepwater Horizon* Gulf oil spill. JSOST *Deepwater Horizon* Oil Spill Principal Investigator (PI) Conference, October 5-6, 2010, St. Petersburg, FL.

Traylor-Holzer, K. 2005. Revised population viability analysis for the Alabama beach mouse *Peromyscus polionotus ammobates*. Report to the U.S. Dept. of the Interior, Fish and Wildlife Service from IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN. 31 pp.

Traylor-Holzer, K., R. Lacy, D. Reed, and O. Byers. 2005. Alabama beach mouse population and habitat viability analysis: Final report. Conservation Breeding Specialist Group, Apple Valley, MN.

Trefry, J.H. 1981. A review of existing knowledge on trace metals in the Gulf of Mexico. In: Proceedings of a symposium on environmental research needs in the Gulf of Mexico (GOMEX). Volume II-B. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratory. Pp. 225-259.

Trefry, J.H. and J.P. Smith. 2003. Forms of mercury in drilling fluid barite and their fate in the marine environment: A review and synthesis. In: Proceedings of the SPE/EPA/DOE Exploration and Production Environmental Conference, March 10-12, 2003, San Antonio, TX. Paper SPE 80571-MS. 10 pp.

Trefry, J.H., K.L. Naito, R.P. Trocine, and S. Metz. 1995. Distribution and bioaccumulation of heavy metals from produced water discharges to the Gulf of Mexico. Water Science and Technology 32(2):31-36.

Trefry, J.H., R.P. Trocine, M.L. McElvaine, R.D. Rember, and L. Hawkins. 2003. Concentrations of total mercury and methylmercury in sediment adjacent to offshore drilling sites. In: Proceedings of the SPE/EPA/DOE Exploration and Production Environmental Conference, March 10-12, 2003, San Antonio, TX. Paper SPE 80569-MS. 12 pp.

Trivelpiece, W.Z., R.G. Butler, D.S. Miller, and D.B. Peakall. 1984. Reduced survival of chicks on oil-dosed adult Leach's storm-petrels. Condor 86:81-82.

Tuler, S., T. Webler, K. Dow, and F. Lord. 2009. Human dimensions impacts of oil spills: Brief summaries of human impacts of oil and oil spill response efforts. Social and Environmental Research Institute. Project funded by the Coastal Response Research Center. Internet website: http://www.seri-us.org/projects/HDOil.html.

Tuler, S., T. Weber, R. Lord, and K. Dow. 2010. A case study into the human dimensions of the DM-932 oil spill in New Orleans. Greenfield MA: Social and Environmental Research Institute. 32 pp.

Tunnell, J.W., Jr., Q.R. Dokken, M.E. Kindinger, and L.C. Thebeau. 1981. Effects of the *Ixtoc I* oil spill on the intertidal and subtidal infaunal populations along lower Texas coast barrier island beaches. In: Proceedings 1981 Oil Spill Conference, March 2-5, Atlanta, GA. Washington DC: American Petroleum Institute. Pp. 467-475.

Turner, R.E. and D.R. Cahoon. 1988. Causes of wetland loss in the coastal Central Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 87-0119 (Volume I: Executive Summary), 87-0120 (Volume II: Technical Narrative), and 87-0121 (Volume III: Appendices). 32, 400, and 122 pp., respectively.

Turner, R.E., R. Costanza, and W. Scaife. 1982. Canals and wetland erosion rates in coastal Louisiana. In: Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services. FWS/OBS 82/59.

Turner, R.E., J.M. Lee, and C. Neill. 1994. Backfilling canals to restore wetlands: Empirical results in coastal Louisiana. Wetlands Ecology and Management 3(1):63-78.

Tuttle, J.R. and A.J. Combe III. 1981. Flow regime and sediment load affected by alterations of the Mississippi River. In: Cross, R.D. and Williams, D.L., eds. Proceedings, National Symposium: Freshwater Inflow Estuaries. U.S. Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services. FWS/OBS-81/104. Pp. 334-348. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3779.pdf.

United Louisiana Vietnamese American Fisherfolks. 2010. Loss of subsistence use claim framework & template for Louisiana Vietnamese American fisherfolks & other Louisiana fisherfolks.

Upton, H.F. 2010. Commercial fishery disaster assistance. Congressional Research Service. Report for Congress. RL 34209. Internet website: http://www.fas.org/sgp/crs/misc/RL34209.pdf.

U.S. Congress, Office of Technology Assessment. 1990. Coping with an oiled sea: an analysis of oil spill response technologies, OTA-BP-O-63, Washington, DC: U.S. Government Printing Office. 70 pp. Internet website: http://www.fas.org/ota/reports/9011.pdf. Accessed December 27, 2010.

U.S. Dept. of Agriculture. Economic Research Service. 2004. County typology codes. Internet website: http://www.ers.usda.gov/Data/TypologyCodes/. Accessed September 20, 2010.

U.S. Dept. of Commerce. 2010. Estimating the economic effect of the deepwater drilling moratorium on the Gulf Coast economy: Inter-agency report, September 16, 2010. Report presented at the Department of Commerce Testimony—111th Congress by Rebecca Blank, Under Secretary for Economic Affairs, U.S. Dept. of Commerce. 25 pp. Internet website: http://www.commerce.gov/sites/default/files/documents/2010/november/blank091610_report.pdf. Accessed December 12, 2010.

U.S. Dept. of Commerce. National Aeronautics and Space Administration. 2003. SeaWiFS Project—detailed description. Internet website: http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/SEAWIFS_970_BROCHURE.html. Updated July 30, 2003. Accessed January 11, 2011.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2007a. Report to Congress on the impact of Hurricanes Katrina, Rita, and Wilma on commercial and recreational fishery habitat of Alabama, Florida, Louisiana, Mississippi, and Texas. July 2007. 191 pp. + apps. Internet website: http://

www.nmfs.noaa.gov/msa2007/docs/HurricaneImpactsHabitat_080707_1200.pdf. Accessed December 30, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2007b. Endangered Species Act Section 7 consultation on the effects of the five-year outer continental shelf oil and gas leasing program (2007-2012) in the Central and Western Planning Areas of the Gulf of Mexico. Biological Opinion. June 29. F/SER/2006/02611. 127 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2008. Information and databases on fisheries landings. Internet website (latest data for 2008): http://www.st.nmfs.gov/st1/commercial/landings/annual_landings.html. Accessed October 6, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010a. Essential fish habitat; a marine fish habitat conservation mandate for Federal agencies. South Atlantic Region. Internet website: http://sero.nmfs.noaa.gov/hcd/pdfs/efhdocs/sa_guide_2010.pdf.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010b. Recovery plan for the sperm whale (*Physeter macrocephalus*). U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD. 165 pp.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010c. Information and databases on fisheries landings. Internet website (latest data for 2009): http://www.st.nmfs.gov/st1/commercial/landings/annual_landings.html. Accessed September 25, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010d. Fisheries economics of the U.S. Internet website: http://www.st.nmfs.noaa.gov/st5/publication/fisheries_economics_2008.html. Accessed December 28, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service. 2010e. Recreational fisheries statistics queries. Internet website: http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. Queried December 1, 2010.

U.S. Dept. of Commerce. National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 1991. Recovery plan for U.S. population of loggerhead turtle. U.S. Dept. of Commerce, National Marine Fisheries Service, Washington, DC. 71 pp.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007a. Leatherback sea turtle (*Dermochelys coriacea*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 79 pp. Internet website: http://www.fws.gov/northflorida/seaTurtles/2007-Reviews/2007-leatherback-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007b. Green sea turtle (*Chelonia mydas*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 102 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-green-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007c. Hawksbill sea turtle (*Eretmochelys imbricata*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 90 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-hawksbill-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007d. Kemp's ridley sea turtle (*Lepidochelys kempii*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological

Service Field Office, Jacksonville, FL. 50 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Kemps-ridley-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2007e. Loggerhead sea turtle (*Caretta caretta*); 5-year review: Summary and evaluation. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD, and U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Service Field Office, Jacksonville, FL. 65 pp. Internet website: http://www.fws.gov/northflorida/SeaTurtles/2007-Reviews/2007-Loggerhead-turtle-5-year-review-final.pdf.

U.S. Dept. of Commerce, National Marine Fisheries Service and U.S. Dept. of the Interior, Fish and Wildlife Service. 2008. Recovery plan for the northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*), second revision. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 1997. Alabama coastal hazards assessment (CD-ROM). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Coastal Service Center, Charleston SC.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2000. Shoreline assessment manual, third edition. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration, Seattle, WA. HAZMAT Report 2000-1. 120 pp. Internet website: http://www.fws.gov/contaminants/FWS_OSCP_05/fwscontingencyappendices/N-Manuals-Response-Assessment/ShorelineAssessment_NOAA.pdf. Accessed February 13, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2005. NOAA attributes recent increase in hurricane activity to naturally occurring multi-decadal climate variability. *NOAA Magazine*. November 29, 2005. Internet website: http://www.magazine.noaa.gov/stories/mag184.htm.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration**.** 2006. NOAA fact sheet, small diesel spills (500-5000 gallons) (Office of Response and Restoration). November 2006. Internet website: http://response.restoration.noaa.gov/book_shelf/974_diesel.pdf.

U.S. Dept. of Commerce. National Oceanic Atmospheric Administration. 2007. National Artificial Reef Plan: Guidelines for siting, construction, development, and assessment of artificial reefs. Internet website: http://www.nmfs.noaa.gov/sfa/PartnershipsCommunications/recfish/NARPREVISION_3_07_07_FINAL.pdf.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2008a. The Gulf of Mexico at a glance. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Washington, DC. 34 pp. Internet website: http://gulfofmexicoalliance.org/pdfs/gulf_glance_1008.pdf. Accessed February 27, 2009.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2008b. Interagency report on marine debris sources, impacts, strategies, and recommendations. Interagency Marine Debris Coordinating Committee, Silver Spring, MD. 62 pp.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2008c. NOAA responds to New Orleans barge collision oil spill. Internet website: http://www.noaanews.noaa.gov/stories2008/20080724_oilspill.html. Accessed November 26, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010a. Using booms in response to oil spills. National Ocean Service. 4 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/NOAA_boom_fact_sheet.pdf. Last revised May 10, 2010. Accessed December 27, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010b. *Deepwater Horizon* oil spill: Characteristics and concerns. 2 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/OilCharacteristics.pdf. Last revised May 15, 2010. Accessed April 29, 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010c. Administration's Joint Analysis Group releases first scientific report on subsea monitoring data from Gulf spill: Provides snapshot of where oil is subsea in vicinity of the wellhead, June 23, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100623_brooks.html. Accessed July 7, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010d. Second Federal analysis gives further clues about location and movement of subsurface oil, July 23, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100722_jag.html. Accessed August 11, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010e. No dead zones observed or expected as part of BP Deepwater Horizon oil spill: Report finds decreased, but stabilized levels of dissolved oxygen in Gulf areas with subsurface oil, September 7, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100907_jag3.html. Accessed January 29, 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010f. Environmental Response Management Application (ERMA). Internet website: http://gomex.erma.noaa.gov. Accessed October 14, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010g. NOAA, U.S., Brazilian partners send ship to study corals, water column for Gulf oil spill response, July 9, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100709_johnson.html. Accessed August 11, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010h. Corals that are candidates for listing under the ESA. U.S. Dept. of Commerce, NOAA Fisheries Office of Protected Resources. Internet website: http://www.nmfs.noaa.gov/pr/species/invertebrates/corals.htm. Accessed December 1, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010i. *Deepwater Horizon*/BP oil spill: Federal fisheries closure and other information. Internet website: http://sero.nmfs.noaa.gov/deepwater_horizon_oil_spill.htm. Accessed September 21, 2010.

U.S. Dept. of Commerce. National Oceanographic and Atmospheric Administration. 2010j. *Deepwater Horizon*/BP oil spill: Size and percent coverage of fishing area closures due to BP oil spill. Internet website. http://sero.nmfs.noaa.gov/ClosureSizeandPercentCoverage.htm. Updated November 15, 2010. Accessed January 13, 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010k. Resources related to Environmental Sensitivity Index (ESI) maps. Internet website: http://response.restoration.noaa.gov/resource_resourcetopic.php?RECORD_KEY(resourcetopics)=resourcetopic_id&resourcetopic_id(resourcetopics)=37 Accessed December 3, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2011a. Threats to marine turtles: Threats in the marine environment. Internet website: http://www.nmfs.noaa.gov/pr/species/turtles/threats.htm. Accessed May 20, 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2011b. NOAA: All federal waters of the Gulf once closed to fishing due to the spill now open: More than 1,000 square miles opened today. Internet website: http://www.noaanews.noaa.gov/stories2011/20110419_gulfreopening.html. Posted April 19, 2011. Accessed May 13, 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. National Hurricane Center. 2006. U.S. mainland hurricane strikes by state, 1851-2004. Internet website: http://www.nhc.noaa.gov/paststate.shtml. Accessed October 24, 2006.

U.S. Dept. of Energy. 2010. Creating an offshore wind industry in the United States: A strategic work plan for the United States Department of Energy, fiscal years 2011 – 2015. U.S. Dept. of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program. September 2,

2010. Internet website: http://www.windpoweringamerica.gov/pdfs/offshore/offshore_wind_strategic_plan.pdf.

U.S. Dept. of Energy. Energy Information Administration. 2006. Natural gas processing: The crucial link between natural gas production and its transportation to market. U.S. Dept. of Energy, Energy Information Administration, Office of Oil and Gas, Washington DC, January 2006.

U.S. Dept. of Energy. Energy Information Administration. 2008. Geothermal energy—energy from the Earth's core. Internet website: http://www.eia.doe.gov/kids/energyfacts/sources/renewable/geothermal.html. Accessed July 19, 2008.

U.S. Dept. of Energy. Energy Information Administration. 2010a. Oil: Crude and petroleum products explained, use of oil. Internet website: http://tonto.eia.doe.gov/energyexplained/index.cfm?page=oil_use. Last updated October 29, 2010. Accessed April 26, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2010b. Crude and petroleum products explained, oil imports and exports. Internet website: http://tonto.eia.doe.gov/energyexplained/index.cfm?page=oil_imports. Last updated November 18, 2010. Accessed April 26, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2010c. Table 6.3. Natural gas imports, exports, and net imports, 1949-2009. Internet website: http://tonto.eia.doe.gov/totalenergy/data/annual/txt/ptb0603.html. Accessed April 26, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2010d. Natural gas explained, where our natural gas comes from. Internet website: http://tonto.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_where. Last updated December 21, 2011. Accessed April 26, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2010e. Gulf of Mexico fact sheet. Internet website: http://www.eia.doe.gov/special/gulf_of_mexico/index.cfm. Updated December 30, 2010. Accessed April 27, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2011a. Natural gas consumption by end use. Internet website: http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm. Last updated March 29, 2011. Accessed April 26, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2011b. Short-term energy and summer fuels outlook. Internet website: http://www.eia.gov/emeu/steo/pub/contents.html#US_Crude_Oil_And_Liquids_Fuels. Posted April 12, 2011. Accessed April 27, 2011.

U.S. Dept. of Health and Human Services. Food and Drug Administration. 2011. Gulf of Mexico oil spill update: Information current as of Monday, May 2, 2011. Internet website: http://www.fda.gov/food/ucm210970.htm. Accessed May 2, 2011.

U.S. Dept. of Homeland Security. Coast Guard. 2010a. Polluting incidents in and around U.S. waters. A spill/release compendium: 1969-2008. Office of Investigations & Compliance Analysis (CG-545), Washington DC. Internet website: http://www.safety4sea.com/admin/images/media/pdf/2010.09.01-Spill_Compendium.pdf. Accessed December 23, 2010.

U.S. Dept. of Homeland Security. Coast Guard. 2010b. Ballast water management. Internet website: http://www.uscg.mil/hq/cg5/cg522/cg5224/bwm.asp. Accessed October 28, 2010.

U.S. Dept. of Homeland Security. Coast Guard. 2010c. *Deepwater Horizon* response daily report, period 91. July 21, 2010. Coast Guard Unified Area Command.

U.S. Dept. of Homeland Security. Coast Guard. 2010d. *Deepwater Horizon* response daily report, period 175. October 12, 2010. Coast Guard Unified Area Command.

U.S. Dept. of Homeland Security. Coast Guard. 2010e. Barataria Bay oil spill. National Response Center. Incident report no. 948993. July 27, 2010.

U.S. Dept. of Labor. Bureau of Labor Statistics. 2010a. Quarterly census of employment and wages for 2001-2009. Internet website: http://www.bls.gov/cew/. Accessed December 1, 2010.

U.S. Dept. of Labor. Bureau of Labor Statistics. 2010b. Fact sheet: Employment in the oil and gas well drilling industry. Internet website: http://www.bls.gov/cew/oil_gas_drilling.htm. Accessed July 1, 2010.

U.S. Dept. of Labor. Occupational Safety and Health Administration. 2010. Keeping workers safe during oil spill response and cleanup operations: Gulf oil response and heat. Internet website: http://www.osha.gov/oilspills/heatstress.html. Accessed January 12, 2011.

U.S. Dept. of the Army. Corps of Engineers. 1992. Planning assistance to States program, Section 22 report, inlets along the Texas Gulf Coast. Galveston District, Southwestern Division, August 1992. 56 pp. Internet website: http://cirp.usace.army.mil/pubs/archive/Inlets_Along_TX_Gulf_Coast.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2002a. Ocean dumping report for calendar 2001: Dredged material. 205 pp. Internet website: http://el.erdc.usace.army.mil/odd/Download_Sites/LC_files/LC_2001.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2002b. Diamondback terrapin (*Malaclemys terrapin* (spp)). Internet website: http://el.erdc.usace.army.mil/tessp/profile.cfm?Type=Freshwater%20Turtles&Name=Diamondback%20Terrapin&View=Species. Accessed October 18, 2010.

U.S. Dept. of the Army. Corps of Engineers. 2004a. Louisiana coastal area (LCA), Louisiana: Ecosystem restoration study. Volume I: LCA Study—main report and Volume II: Programmatic environmental impact statement. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, New Orleans, LA. 506 and 918 pp., respectively. Internet website: http://www.lca.gov/Library/ProductList.aspx?Prodtype=0&folder=1118. Accessed March 18, 2011.

U.S. Dept of the Army. Corps of Engineers. 2004b. Barataria-Plaquemines barrier island complex project CWPPRA project Fed No/BA-38 Pass La Mer to Chaland Pass and Pelican Island: Environmental assessment. New Orleans District, New Orleans, LA. 89 pp. + apps. Internet website: http://lacoast.gov/reports/env/BA-38ea304.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2005a. U.S. Army Corps of Engineers response to Hurricanes Katrina & Rita in Louisiana. Environmental Assessment EA #433. Internet website: http://www.nolaenvironmental.gov/nola_public_data/projects/usace_levee/docs/original/KatrinaRitaEAJune_8_06.pdf. Accessed September 2006.

U.S. Dept. of the Army. Corps of Engineers. 2005b. Corps emergency permitting procedures due to hurricanes. Internet website: http://www.nolaenvironmental.gov/nola_public_data/projects/usace_levee/docs/original/KatrinaRitaEAJune_8_06.pdf. Accessed December 1, 2010.

U.S. Dept. of the Army. Corps of Engineers. 2008. Maintenance dredging and disposal of dredged materials Mississippi and Louisiana portions of the Gulf Intracoastal Waterway federally authorized navigation project: Draft environmental assessment, January 2008. Mobile District Office, Mobile, AL. 232 pp. Internet website: http://www.sam.usace.army.mil/pd/EAs/GIWW_DRAFTEAforPUBLIC(2)jj.pdf. Accessed May 20, 2011.

U.S. Dept. of the Army. Corps of Engineers, 2009a. Louisiana coastal protection and restoration: Final technical report and comment addendum—programmatic cumulative effects analysis appendix. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, Mississippi Valley Division. 49 pp. with annexes. Internet website: http://lacpr.usace.army.mil/FinalReport/Vol%20IV/Programmatic%20Cumulative%20Effects%20Analysis.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2009b. Louisiana coastal protection and restoration: Final technical report and comment addendum—main report. U.S. Dept. of the Army, Corps of Engineers, New Orleans District, Mississippi Valley Division. 265 pp. with attachments. Internet website: http://lacpr.usace.army.mil/default.aspx?p=LACPR_Final_Technical_Report.

U.S. Dept. of the Army. Corps of Engineers. 2009c. Corps hurricane response. Task Force Hope Status Report Newsletter. December 14, 2009. 8 pp. Internet website: http://www.mvn.usace.army.mil/hps2/pdf/Dec_14_2009.pdf.

U.S. Dept. of the Army. Corps of Engineers. 2010. Draft supplemental environmental assessment for the beach erosion control and storm damage reduction project, Panama City Beach, Bay County. Mobile District, Planning and Environmental Division, Environmental Resources Branch, Coastal Environment Team. 27 pp.

U.S. Dept. of the Army. Corps of Engineers. 2011a. Amount of dredged material ocean disposed by year in cubic yards by single district. Internet website: http://el.erdc.usace.army.mil/odd/. Stated as current through 2008. Accessed January 27, 2011.

U.S. Dept. of the Army. Corps of Engineers. 2011b. United States of America ocean dumping report for calendar year 2008 dredged material. Headquarters, Washington DC. Internet website: http://el.erdc.usace.army.mil/odd/file.htm. Stated as current through 2008. Accessed January 27, 2011.

U.S. Dept. of the Interior. 2010. Increased safety measures for energy development on the outer continental shelf, May 27, 2010. U.S. Dept. of the Interior, Washington, DC. 44 pp. Internet website: http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=33598.

U.S. Dept. of the Interior. Bureau of Land Management. 1982. *Ixtoc I* oil spill economic impact study. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA. Study no. 1982-33.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010a. Modifications to suspension of deepwater drilling operations: Environmental assessment and finding of no significant impact (October 12, 2010). U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Herndon, VA. 43 pp. Internet website: http://www.boemre.gov/eppd/PDF/EAModificationsSuspension10122010.pdf.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010b. Fact sheet: The workplace safety rule on safety and environmental management systems (SEMS). U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. 2 pp. Internet website: http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=45791.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010c. Technical Information Management System (TIMS). Accessed September 13, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010d. BOEMRE issues guidance for deepwater drillers to comply with strengthened safety and environmental standards. Press Release and Document. December 13, 2010. 18 pp. Internet website: http://www.boemre.gov/ooc/press/2010/press1213.htm. Accessed December 27, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010e. Loss of well control—statistics and summaries 2006-2010. Internet website: http://www.boemre.gov/incidents/blowouts.htm. Updated November 19, 2010. Accessed December 15, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010f. BOEMRE website incident statistics and summaries 1996-2010. Internet website: http://www.boemre.gov/incidents/IncidentStatisticsSummaries.htm. Specifically accessed the page Gulf of Mexico Region Spills ≥ 50 Barrels (2,100 gallons)—2007: http://www.boemre.gov/incidents/SigPoll2007.htm. Accessed November 11, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010g. BOEMRE website incident statistics and summaries 1996-2010. Internet websites: http://www.boemre.gov/incidents/IncidentStatisticsSummaries.htm. Specifically accessed the page Gulf of Mexico Region Spills ≥ 50 Barrels (2,100 gallons)—2008: http://www.boemre.gov/incidents/SigPoll2008.htm. Accessed November 30, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010h. Questions, answers, and related resources. Internet website: http://www.gomr.boemre.gov/homepg/offshore/egom/faq.html. Accessed October 5, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010i. Summary OCS spills of 50 barrels (2,100 gallons) and greater, calendar year 1964-2009. Internet website: http://www.boemre.gov/incidents/spills1964-1995.htm. Accessed November 24, 2010.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010j. Federal and academic scientists return from deep-sea research cruise in Gulf of Mexico: Scientists observe damage to deep-sea corals. Press Release. November 4, 2010. Internet website: http://www.boemre.gov/ooc/press/2010/press1104a.htm. Accessed November 24, 2010.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1985a. Endangered and threatened wildlife and plants; determination of endangered status and critical habitat for three beach mice; final rule. *Federal Register* 50 FR 109, pp. 23872-23889.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1985b. Critical habitat designation Choctawhatchee beach mouse. 50 CFR 1 §17.95.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1987. Recovery plan for the Choctawhatchee, Perdido Key, and Alabama beach mouse. U.S. Dept. of the Interior, Fish and Wildlife Service, Atlanta, GA. 45 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1994. Whooping crane recovery plan (second revision). U.S. Dept. of the Interior, Fish and Wildlife Service, Albuquerque, NM. 92 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1998. Endangered and threatened wildlife and plants. 50 CFR 17.11 and 17.12. December 31, 1998. 56 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 1999. National wetlands inventory: 1996 coastal Mississippi habitat data. U.S. Dept. of the Interior, Fish and Wildlife Service, National Wetlands Center, Lafayette, LA.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2000. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 28 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2002. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 34 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2003. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 46 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2004a. Hurricane Ivan wreaks havoc on southeast refuges 2004. Environmental Contaminants Program. Internet website: http://www.fws.gov/contaminants/DisplayNews.cfm?NewsID=3953873A-54D8-4997-A9EF22BA218F7275. Posted September 24, 2004. Accessed April 14, 2011.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2004b. Preliminary assessment of Alabama beach mouse (*Peromyscus polionotus ammobates*) distribution and habitat following Hurricane Ivan. U.S. Dept. of the Interior, Fish and Wildlife Service, Daphne, AL. 18 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2004c. Model evaluation for predicting hurricane effects on Alabama beach mouse habitat: Technical support to the Daphne Ecological Services Field Office, Vero Beach, FL. 17 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2004d. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 47 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2005a. Preliminary assessment of Alabama beach mouse (*Peromyscus polionotus ammobates*) distribution and habitat following the 2005 hurricane season. U.S. Dept. of the Interior, Fish and Wildlife Service, Daphne, AL. 18 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2005b. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 52 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2006a. Endangered and threatened wildlife and plants; critical habitat for the Alabama beach mouse: Proposed rule. 50 CFR 17 RIN 1018-AU46. *Federal Register* 71:21.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2006b. Fisheries resources annual report. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 48 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2006c. Biological opinion and conference report on the U.S. Army Corps of Engineers, Mobile District, interim operating plan for Jim Woodruff Dam and the associated releases to the Apalachicola River. U.S. Dept. of the Interior, Fish and Wildlife Service, Panama City, FL. 166 pp.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; removal of the brown pelican (*Pelecanus occidentalis*) from the federal list of endangered and threatened wildlife. *Federal Register*, Volume 74, pp. 59443-59472; 50 CFR 17, RIN 1018-AV28.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010a. *Deepwater Horizon* oil spill response (spill by the numbers section). Internet website: http://www.fws.gov/home/dhoilspill/. Accessed September 27, 2010. -------- (FWS oil spill response weekly update. Report for the week of Saturday, September 25 – Friday, September 30, 2010. http://www.fws.gov/home/dhoilspill/)

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010b. Species report. Chapter 4. Internet website: http://ecos.fws.gov/tess_public/SpeciesReport.do. Accessed on August 30, 2010.

U.S. Dept. of the Interior, Fish and Wildlife Service and Gulf States Marine Fisheries Commission. 1995. Gulf sturgeon (*Acipenser oxyrinchus desotoi*) recovery/management plan. Prepared by the Gulf Sturgeon Recovery/Management Task Team for the U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Atlanta, GA; the Gulf States Marine Fisheries Commission, Ocean Springs, MS; and the U.S. Dept. of Commerce, National Marine Fisheries Service, Washington, DC.

U.S. Dept. of the Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, National Marine Fisheries Service. 2009. Gulf sturgeon (*Acipenser oxyrinchus desotoi*)—5-year review: Summary and evaluation. U.S. Dept. of the Interior, Fish and Wildlife Service, Southeast Region, Panama City Ecological Services Field Office, Panama City, FL, and U.S. Dept. of Commerce, National Marine Fisheries Service, Southeast Region, Office of Protected Species, St. Petersburg, FL. 49 pp. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/species/gulfsturgeon_5yearreview.pdf.

U.S. Dept. of the Interior. Geological Survey. 1988. Report to Congress: Coastal barrier resource system. Recommendations for additions to or deletions from the Coastal Barrier Resource System. Vol. 18, Louisiana.

U.S. Dept. of the Interior. Geological Survey. 1998. Chandeleur Islands, La.—1992 submerged aquatic vegetation. Geospatial_Data_Presentation_Form: Map. Maintained by the U.S. Dept. of the Interior, Geological Survey, National Wetlands Research Center.

U.S. Dept. of the Interior. Geological Survey. 2004. Seagrass habitat in the northern Gulf of Mexico: Degradation, conservation and restoration of a valuable resource. U.S. Dept. of the Interior, Geological Survey, Gulf of Mexico Program, 855-R-04-001. Internet website: http://gulfsci.usgs.gov/gom_ims/pdf/pubs_gom.pdf.

U.S. Dept. of the Interior. Geological Survey. 2006. Post Hurricane Katrina flights over Louisiana's barrier islands. U.S. Dept. of the Interior, Geological Survey, National Wetlands Research Center, Lafayette, LA. Internet website: http://www.nwrc.usgs.gov/hurricane/katrina_rita/katrina-post-hurricane-flights.htm. Accessed May 19, 2011.

U.S. Dept. of the Interior. Geological Survey. 2008. Coastal change hazards: Hurricanes and extreme storms. Internet website: http://coastal.er.usgs.gov/hurricanes/. Accessed April 15, 2011.

U.S. Dept. of the Interior. Geological Survey. 2010a. Summary of the water cycle. Internet website: http://ga.water.usgs.gov/edu/watercyclesummary.html. Accessed October 4, 2010.

U.S. Dept. of the Interior. Geological Survey. 2010b. NAS—nonindigenous aquatic species. *Pterois volitans/miles*. Internet website: http://nas.er.usgs.gov/queries/collectioninfo.aspx?NoCache=8%2F11%2F2009+10%3A53%3A53+AM&SpeciesID=963&State=&County=&HUCNumber=. Accessed October 18, 2010.

U.S. Dept. of the Interior. Minerals Management Service. 1987. Programmatic environmental assessment: Structure removal activities, Central and Western Gulf of Mexico Planning Areas. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 87-0002. 84 pp.

U.S. Dept. of the Interior. Minerals Management Service. 1997. Gulf of Mexico OCS oil and gas lease Sales 169, 172, 175, 178 and 182: Central Planning Area—final environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 97-0033.

U.S. Dept. of the Interior. Minerals Management Service. 2000. Gulf of Mexico deepwater operations and activities: Environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-001. 264 pp. Internet website: http://www.gomr.boemre.gov/PDFs/2000/2000-001.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2001a. Proposed use of floating production, storage, and offloading systems on the Gulf of Mexico outer continental shelf, Western and Central Planning Areas—final environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2000-090. 782 pp. Internet website: http://www.gomr.boemre.gov/PDFs/2000/2000-090.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2001b. Gulf of Mexico oil and gas Lease Sale 181: Eastern Planning Area—final environmental impact statement. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2001-051.

U.S. Dept. of the Interior. Minerals Management Service. 2001c. Outer continental shelf oil & gas leasing program: 2002-2007—draft environmental impact statement, October 2001. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS EIS/EA MMS 2001-079.

U.S. Dept. of the Interior. Minerals Management Service. 2002a. NTL No. 2002-G13: Marine trash and debris awareness and elimination. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Internet website: http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/ntl03-g06.html. Accessed March 18, 2011.

U.S. Dept. of the Interior. Minerals Management Service. 2002b. Gulf of Mexico OCS oil and gas lease sales: 2003-2007; Central Planning Area Sales 185, 190, 194, 198, and 201; Western Planning Area Sales 187, 192, 196, and 200—draft environmental impact statement. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2002-015.

U.S. Dept. of the Interior. Minerals Management Service. 2005. Structure-removal operations on the Gulf of Mexico outer continental shelf—programmatic environmental assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2005-013.

U.S. Dept. of the Interior. Minerals Management Service. 2006a. Planning area resources addendum to assessment of undiscovered technically recoverable oil and gas resources of the Nation's outer continental shelf, 2006. MMS Fact Sheet RED-2006-02, July 2006. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. 2 pp. Internet website: http://www.boemre.gov/revaldiv/PDFs/NA2006BrochurePlanningAreaInsert.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2006b. Deepwater Gulf of Mexico 2006: America's expanding frontier. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2006-022. 144 pp. Internet website: http://www.gomr.boemre.gov/homepg/whatsnew/techann/2006/2006-022.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2007a. Proposed final program: Outer continental shelf oil and gas leasing program, 2007-2012 (April 2007). U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. 146 pp. Internet website: http://www.boemre.gov/5-year/PDFs/MMSProposedFinalProgram2007-2012.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2007b. Gulf of Mexico OCS oil and gas lease sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222—final environmental impact statement. 2 vols. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2007-018. Internet website: http://www.gomr.BOEMRE.gov/PDFs/2007/2007-018-Vol1.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2007c. Outer continental shelf oil and gas leasing program: 2007-2012—final environmental impact statement. Volumes I-II. U.S. Dept. of the Interior, Minerals Management Service, Washington, DC. OCS EIS/EA MMS 2007-003. Internet website: http://www.BOEMRE.gov/5-year/PDFs/MMSProposedFinalProgram2007-2012.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2007d. Gulf of Mexico OCS oil and gas scenario examination: Pipeline landfalls. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2007-053. 8 pp. Internet website: http://www.gomr.mms.gov/PDFs/2007/2007-053.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2007e. Gulf of Mexico OCS oil and gas scenario examination: Exploration and development activity. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2007-052. 14 pp.

U.S. Dept. of the Interior. Minerals Management Service. 2007f. Final programmatic environmental impact statement for alternative energy development and production and alternate use of facilities on the outer continental shelf. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS EIS/EA 2007-046.

U.S. Dept. of the Interior. Minerals Management Service. 2008a. Gulf of Mexico OCS oil and gas lease sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218—final supplemental environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2008-041.

U.S. Dept. of the Interior. Minerals Management Service. 2008b. Preliminary evaluation of in-place gas hydrate resources: Gulf of Mexico outer continental shelf. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2008-004. Internet website: http://www.mms.gov/revaldiv/GasHydrateFiles/MMS2008-004.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2008c. NTL No. 2008-G05: Shallow hazards program. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Internet website: http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2008NTLs/08-g05.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2009a. Petroleum spills from Federal outer continental shelf oil and gas facilities caused by major hurricanes, 2002 to 2008: Lili (2002), Ivan (2004), Katrina (2005), Rita (2005), Gustav (2008) and Ike (2008). September 24, 2009. Internet website: http://www.boemre.gov/incidents/PDFs/Hurricanes2002to2008.pdf. Accessed March 18, 2011.

U.S. Dept. of the Interior. Minerals Management Service. 2009b. NTL No. 2009-G39: Biologically-sensitive underwater features and areas. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Internet website: http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G39.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2009c. NTL No. 2009-G40: Deepwater benthic communities. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Internet website: http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G40.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2009d. Rigs to reefs policy addendum: Enhanced reviewing and approval guidelines in response to the post-Hurricane Katrina regulatory environment. Related document, OCS Report MMS 2000-073. Internet website: http://www.gomr.boemre.gov/homepg/regulate/environ/rigs-to-reefs/Rigs-to-Reefs-Policy-Addendum.pdf.

U.S. Dept. of the Interior. Minerals Management Service. 2009e. NTL 2009-G35: Sub-seabed disposal and offshore storage of solid wastes. Internet website: http://www.gomr.boemre.gov/homepg/regulate/regs/ntls/2009NTLs/09-G35.pdf.

U.S. Dept. of the Interior. National Park Service. 2005. November 2005 archeology e-gram. Internet website: http://www.nps.gov/archeology/pubs/egrams/0511.pdf. Accessed July 20, 2010.

U.S. Dept. of the Interior. National Park Service. 2010. Experience America's best idea: National park getaways; Gulf Islands National Seashore, Florida & Mississippi. Internet website: http://www.nps.gov/getaways/guis/. Accessed April 14, 2011.

U.S. Dept. of the Interior. Office of Public Affairs. 2010a. Salazar calls for new safety measures for offshore oil and gas operations; orders six month moratorium on deepwater drilling. May 27, 2010. Internet website: http://www.boemre.gov/ooc/press/2010/press0527.htm. Accessed November 16, 2010.

U.S. Dept. of the Interior. Office of Public Affairs. 2010b. Readout of BOEMRE Director Bromwich's meeting with shallow water drilling coalition. September 14, 2010. Internet website: http://www.boemre.gov/ooc/press/2010/press0914.htm. Accessed November 16, 2010.

U.S. Dept. of Transportation. 2010. Gulf Coast ports surrounding the deepwater horizon oil spill. June 2010. Research and Innovative Technology Administration. Internet website: http://www.bts.gov/publications/bts_fact_sheets/2010_001/pdf/entire.pdf. Accessed August 31, 2010.

U.S. Dept. of Transportation. Coast Guard. 2003. Final environmental impact statement for the Port Pelican LLC deepwater port license application. Commandant, U.S. Dept. of Transportation, Coast Guard, Washington, DC.

U.S. Dept. of Transportation. Federal Highway Administration. 2004. Louisiana 1 improvements: Golden Meadow to Port Fourchon. Revised Record of Decision. Internet website: http://www.dotd.state.la.us/press/LA1_ROD_Addm.pdf. Accessed November 19, 2010.

U.S. Dept. of Transportation. National Transportation Safety Board. 1998. Safety recommendation M-98-124. Internet website: http://www.ntsb.gov/Recs/letters/1998/M98_124.pdf. Accessed October 2003.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2009. Vessel calls snapshot, 2009. 10 pp. Internet website: http://www.marad.dot.gov/documents/Vessel_Calls_at_US_Ports_Snapshot.pdf.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2010. Deepwater port licensing program: Pending applications. Internet website: http://www.marad.dot.gov/ports_landing_page/deepwater_port_licensing/dwp_planned_ports/dwp_planned_ports.htm. Accessed September 30, 2010.

U.S. Environmental Protection Agency. 2000a. Environmental assessment of final effluent limitation guidelines and standards for synthetic-based drilling fluids and other non-aqueous drilling fluids in

the oil and gas extraction point source category. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-821-B-00-014. 184 pp.

U.S. Environmental Protection Agency. 2000b. Sector notebook project: Oil and gas extraction. 51 pp. Internet website: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/oilgaspt1.pdf.

U.S. Environmental Protection Agency. 2001. Coastal condition report. EPA-620/R-01/005. Internet website: http://www.epa.gov/owow/oceans/nccr/downloads.html. Accessed August 24, 2009.

U.S. Environmental Protection Agency. 2002. Exemption of oil and gas exploration and production wastes from federal hazardous waste regulations. U.S. Environmental Protection Agency, Office of Solid Wastes, Washington, DC. EPA530-K-01-004. 40 pp. Internet website: http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf.

U.S. Environmental Protection Agency. 2004a. Final NPDES general permit for new and existing sources and new dischargers in the offshore subcategory of the oil and gas extraction category for the western portion of the outer continental shelf of the Gulf of Mexico (GMG290000). U.S. Environmental Protection Agency. 117 pp. Internet website: http://www.epa.gov/region6/water/npdes/genpermit/gmg290000finalpermit2004.pdf.

U.S. Environmental Protection Agency. 2004b. Toolkit for assessing potential allegations of environmental injustice. Internet website: http://www.epa.gov/environmentaljustice/resources/policy/ej-toolkit.pdf. Accessed January 22, 2011.

U.S. Environmental Protection Agency. 2005. Coastal condition report II. EPA-620/R-03/002. Internet website: http://www.epa.gov/owow/oceans/nccr/2005/downloads.html/. Accessed August 24, 2009.

U.S. Environmental Protection Agency. 2007a. Region 6 compliance assurance and enforcement, offshore and oil and gas NPDES permits. Internet website: http://www.epa.gov/earth1r6/6en/w/offshore/home.htm. Accessed November 26, 2010.

U.S. Environmental Protection Agency. 2007b. National Estuary Program coastal condition report. U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Washington DC. EPA-842/B-06/001. Internet website: http://water.epa.gov/type/oceb/nep/nepccr_index.cfmAccessed February 1, 2008.

U.S. Environmental Protection Agency. 2007c. USEPA Region 6 NPDES OCS general permit no. GMG290000. Internet website: http://www.epa.gov/earth1r6/6en/w/offshore/permit10012007.pdf. Accessed April 28, 2009.

U.S. Environmental Protection Agency. 2007d. NPDES general permit for new and existing sources and new dischargers in the offshore subcategory of the oil and gas extraction category for the western portion of the outer continental shelf of the Gulf of Mexico (GMG290000). U.S. Environmental Protection Agency. 15 pp. Internet website: http://www.epa.gov/Region06/water/npdes/genpermit/gmg290000fedreg.pdf.

U.S. Environmental Protection Agency. 2008a. Coastal condition report III. EPA/842-R-08-002. Internet website: http://www.epa.gov/nccr/. Accessed February 27, 2009.

U.S. Environmental Protection Agency. 2008b. National Pollutant Discharge Elimination System (NPDES), vessel discharges, final vessel general permit. 5 pp. Internet website: http://cfpub.epa.gov/npdes/home.cfm?program_id=350. Updated December 15, 2008. Accessed April 20, 2009.

U.S. Environmental Protection Agency. 2009a. Region 4 environmental assessment for the National Pollutant Discharge Elimination System permitting for eastern Gulf of Mexico offshore oil and gas exploration, development and production. Permit 904/P-09-001. 129 pp. Internet website: http://www.epa.gov/region04/water/permits/documents/ea_12_09_09.pdf.

U.S. Environmental Protection Agency. 2009b. Draft National Pollutant Discharge Elimination System (NPDES) general permit no. GEG460000 for offshore oil and gas activities in the Eastern Gulf of

Mexico. 186 pp. Internet website: http://www.epa.gov/region4/water/permits/documents/draft_r4_ocspermit_v24fr_10152009.pdf. Accessed January 12, 2009.

U.S. Environmental Protection Agency. 2010a. EPA response to BP spill in the Gulf of Mexico. Air data from the Gulf coastline. Internet website: http://www.epa.gov/bpspill/air.html. Accessed December 1, 2010.

U.S. Environmental Protection Agency. 2010b. Region 4 air permits. Internet website: http://www.epa.gov/region4/air/permits/index.htm. Accessed November 2010.

U.S. Environmental Protection Agency. 2010c. Greenhouse gas reporting program. Internet website: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html. Accessed February 1, 2011.

U.S. Environmental Protection Agency. 2010d. Particulate matter. Internet website: http://www.epa.gov/pm/. Accessed December 2, 2010.

U.S. Environmental Protection Agency. 2010e. Odors from the BP oil spill. Internet website: http://www.epa.gov/BPSpill/odor.html. Accessed October 1, 2010.

U.S. Environmental Protection Agency. 2010f. Coastal water sampling. Internet website: http://www.epa.gov/bpspill/water.html. Accessed July 9, 2010.

U.S. Environmental Protection Agency. 2010g. Coastal sediment sampling. Internet website: http://www.epa.gov/bpspill/sediment.html. Accessed July 9, 2010.

U.S. Environmental Protection Agency. 2010h. BP's analysis of subsurface dispersant use. Internet website: http://www.epa.gov/bpspill/dispersants-bp.html. Accessed July 9, 2010.

U.S. Environmental Protection Agency. 2010i. Water quality standards for the State of Florida's lakes and flowing waters. Internet website: http://www.epa.gov/waterscience/standards/rules/florida/factsheet.html. Accessed March 9, 2010.

U.S. Environmental Protection Agency. 2010j. Oil and gas NPDES permits. Internet website: http://www.epa.gov/region04/water/permits/oil_gas.html. Last updated January 15, 2010. Accessed November 26, 2010.

U.S. Environmental Protection Agency. 2010k. Recovered oil, contaminated materials and liquid and solid wastes management directive, June 29, 2010 (Louisiana). 9 pp. Internet website: http://www.epa.gov/bpspill/waste/wastemanagementdirective_la.pdf. Accessed August 31, 2010.

U.S. Environmental Protection Agency. 2010l. Recovered oil, contaminated materials and liquid and solid wastes management directive, June 29, 2010 (Mississippi, Alabama, Florida). 10 pp. Internet website: http://www.epa.gov/bpspill/waste/wastemanagementdirective_msalfl.pdf. Accessed August 31, 2010.

U.S. Environmental Protection Agency. 2010m. Waste staging and decontamination areas in Alabama, Florida, Louisiana and Mississippi, June 28-October 4. Internet website: http://www.epa.gov/bpspill/data/waste_facility_assessments.pdf. Accessed October 10, 2010.

U.S. Environmental Protection Agency. 2011a. National Ambient Air Quality Standards (NAAQS). Internet website: http://www.epa.gov/air/criteria.html. Last updated April 18, 2011. Accessed April 26, 2011.

U.S. Environmental Protection Agency. 2011b. 8-hour ozone nonattainment area/state/county report. Internet website: http://www.epa.gov/oaqps001/greenbk/gnca.html. Last updated April 21, 2011. Accessed April 26, 2011.

U.S. Environmental Protection Agency and U.S. Dept. of Army, Corps of Engineers. 2003. Ocean Dredged Material Disposal Program: Regional implementation agreement. USEPA Region 6, USACOE Galveston District, USACOE New Orleans District. July 2003. Internet website: http://www.epa.gov/region6/water/ecopro/em/ocean/ria.pdf.

U.S. Government Accountability Office. 2007. Coastal wetlands: Lessons learned from past efforts in Louisiana could help guide future restoration and protection. Government Accountability Office, Washington DC. GAO 08-130. 62 pp. Internet website: http://www.gao.gov/new.items/d08130.pdf.

U.S. House of Representatives. Committee on Energy and Commerce. Subcommittee on Commerce, Trade, and Consumer Protection. 2010. The BP oil spill and the Gulf Coast tourism: Assessing the impact. Internet website: https://hsdl.org/?view&doc=126706&coll=limited.

U.S. Travel Association. 2010. Economic impact of travel and tourism. The Power of Travel Data Center. Internet website: http://poweroftravel.org/statistics.

Valentine, J. 2010. Personal communication. Media reports of fisheries closures offsetting population losses from the spill. Senior Marine Scientist & Associate Professor, Dauphin Island Sea Lab and University of South Alabama. November 18, 2010.

Valentine, D.L., J.D. Kessler, M.C. Redmond, S.D. Mendes, M.B. Heintz, C. Farwell, L. Hu, F.S. Kinnaman, S. Yvon-Lewis, M. Du, E.W. Chan, F. Garcia Tigreros, and C.J. Villaneuva. 2010. Propane respiration jump-starts microbial response to a deep oil spill. Science Express. 9 pp. Internet website: http://ecosystems.mbl.edu/mbl_micro_eco/pdf/Valentine2010.pdf. Posted September 16, 2010. Accessed March 18, 2011.

Vandermuelen, J.H. 1982. Some conclusions regarding long-term effects of some major oil spills. Philosophical Transactions of the Royal Society of London. Series B, Biological Communities and Ecosystems 297(1087):335-351.

Vandegrift, K.J., S.H. Sokolow, P. Daszak, and A.M. Kilpatrick. 2010. Ecology of avian influenza viruses in a changing world. Annals of the New York Academy of Sciences 1195:113-128.

Varanasi, U., J.E. Stein, L.L. Johnson, T.K. Collier, E. Casillas, and M.S. Myers. 1992. Evaluation of bioindicators of contaminant exposure and effects in coastal ecosystems. In: McKenzie, D.H., D.E. Hyatt, and V.J. McDonald, eds. Ecological indicators, Volume 1. Proceedings of an International Symposium, Fort Lauderdale, FL.

Vashcenko, M.A. 1980. Effects of oil pollution on the development of sex cells in sea urchins. Biologische Anstalt Helgoland 297-300.

Veil, J.A., M.G. Puder, D. Elcock, and R.J. Redweik, Jr. 2004. A white paper describing produced water from production of crude oil, natural gas, and coal bed methane. Prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy, National Energy Technology Laboratory, Contract W-31-109-Eng-38. 79 pp. Internet website: http://www.ead.anl.gov/pub/dsp_detail.cfm?PubID=1715.

Velando, A., D. Alvarez, J. Mourino, F. Arcos, and A. Barros. 2005a. Population trends and reproductive success of the European shag *Phalacrocorax aristotelis* on the Iberian Peninsula following the *Prestige* oil spill. Journal of Ornithology 146:116-120.

Velando, A., I. Munilla, and P.M. Leyenda. 2005b. Short-term indirect effects of the 'Prestige' oil spill on European shags: Changes in availability of prey. Marine Ecology Progress Series 302:263-274.

Visit Florida Research. 2010. Research. Internet website: http://media.visitflorida.org/research.php. Accessed December 10, 2010.

Visser, J.M. and G.W. Peterson. 1994. Breeding populations and colony site dynamics of seabirds nesting in Louisiana. Colonial Waterbirds 17:146-152.

Vittor, B.A. 2000. Benthic macroinfauna of the northeastern Gulf of Mexico OCS, near DeSoto Canyon. In: Schroeder, W.W. and C.F. Wood, eds. Physical/Biological Oceanographic Integration Workshop for the DeSoto Canyon and Adjacent Shelf, October 19-21, 1999. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-074. 168 pp.

Vladykov, V.D. 1955. A comparison of Atlantic sea sturgeon with a new subspecies from the Gulf of Mexico (*Acipenser ovyrhynchus desotoi*). Journal of the Fisheries Research Board of Canada 12:754-761.

Vladykov, V.D. and J.R. Greeley. 1963. Order Acipenseroidei. In: Fishes of the western North Atlantic. Memoirs of the Sears Foundation for Marine Research 1:24-60.

Wallace, R.K. 1996. Coastal wetlands in Alabama. Auburn University, Marine Extension and Research Center, Mobile, AL. Circular ANR-831 MASGP-96-018.

Wallace, B., J. Kirkley, T. McGuire, D. Austin, and D. Goldfield. 2001. Assessment of historical, social, and economic impacts of OCS development on Gulf Coast communities. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2001-026. 12 pp.

Wang, F.C. 1988. Saltwater intrusion modeling: The role of man-made features. In: Turner, R.E. and D.R. Cahoon, eds. Causes of wetland loss in the coastal central Gulf of Mexico. Volume 2. U.S. Dept. of the Interior, Minerals Management Service, New Orleans, LA. OCS Study MMS 87-0120. Pp. 71-100.

Wang, P. and T. Roberts. 2010. Ongoing beach cleanup of the BP oil spill—a superficial job, literally. University of South Florida, Dept. of Geology, Coastal Research Laboratory, Tampa, FL.. 15 pp. Internet website: http://news.usf.edu/article/articlefiles/2566-PW%202nd%20Beach%20report.pdf.

Wang, D.W., S.A. Mitchell, W.J. Teague, E. Jarosz, and M.S. Hulbert. 2005. Extreme waves under Hurricane Ivan. Science 3009:896.

Ward, G.A., B. Baca, W. Cyriacks, R.E. Dodge, and A. Knap. 2003. Continuing long-term studies of the TROPICS Panama oil and dispersed oil spill sites. In: Proceedings of the 2003 International Oil Spill Conference, April 2-10, 2003, Vancouver, British Columbia.

Warham, J. 1990. The petrels: Their ecology and breeding systems. San Diego, CA: Academic Press. 440 pp.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2009. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2009. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NMFS NE 213. 528 pp.

Wartzok, D. and D.R. Ketten. 1999. Marine mammal sensory systems. In: Reynolds, J.E. and S.A. Rommel, eds. Biology of marine mammals. Washington, DC: Smithsonian Institution Press. Pp. 117-175.

Weatherly, G. 2004. Intermediate depth circulation in the Gulf of Mexico: PALACE float results for the Gulf of Mexico between April 1998 and March 2002. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OSC Region, New Orleans, LA. OCS Study MMS-2004-013. 51 pp.

Weaver, D.C., G.D. Dennis, and K.J. Sulak. 2002. Northeastern Gulf of Mexico coastal marine ecosystem program: Community structure and trophic ecology of demersal fishes on the pinnacle reef tract: Final synthesis report. U.S. Dept. of the Interior, Geological Survey, USGS BSR-2001-008 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-034. 143 pp.

Weaver, D.C., E.L. Hickerson, and G.P. Schmahl. 2006. Deep reef fish surveys by submersible on Alderice, McGrail, and Sonnier Banks in the northwestern Gulf of Mexico. In: Emerging Technologies for Reef Fisheries Research and Management. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Seattle, WA. NOAA Professional Paper NMFS (5). Pp. 69-87.

Webb, J.W. 1988. Establishment of vegetation on oil-contaminated dunes. Shore and Beach, October. Pp. 20-23.

Webb, T. 2010. BP oil spill: Failed safety device on *Deepwater Horizon* rig was modified in China. *The Observer*. Internet website: http://www.guardian.co.uk/environment/2010/jul/18/deepwater-horizon-blow-out-preventer-china. Posted July 18, 2010. Accessed September 22, 2010.

Webb, J.W., S.K. Alexander, and J.K. Winters. 1985. Effects of autumn application of oil on *Spartina alterniflora* in a Texas salt marsh. Environ. Poll. Series A. 38(4):321-337.

Webster, P. J., G.J. Holland, J.A. Curry, and H.R. Chang. 2005. Changes in tropical cyclone number, duration and intensity in a warming environment. Science 309:1844–1846.

Weinstein, B.L. 2010. The economic and fiscal consequences of the drop in shallow-water drilling permits: Impacts on the Gulf Coast and the Nation. Southern Methodist University, Maguire Energy Institute, Cox School of Business. September 2010. Internet website: http://pressdocs.cox.smu.edu/maguire/Maguire%20Institute%20Shallow%20Water%20Report%209-10.pdf. Accessed November 28, 2010.

Weir, R.D. 1976. Annotated bibliography of bird kills at man-made obstacles: A review of the state of the art and solutions. Canadian Wildlife Service, Ottawa.

Welsh, S.E., M. Inoue, L.J. Rouse, Jr., and E. Weeks. 2009. Observation of the deepwater manifestation of the Loop Current and Loop Current rings in the eastern Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-050. 110 pp.

Wells, R.J.D. and J.R. Rooker. 2004. Spatial and temporal habitat use by fishes associated with Sargassum mats in the NW Gulf of Mexico. Bulletin of Marine Science 74:81-99

Wesseling, I., A.J. Uychiacoc, P.M. Aliño, T. Aurin, and J.E. Vermaat. 1999. Damage and recovery of four Philippine corals from short-term sediment burial. Marine Ecology Progress Series 176:11-15.

West Engineering Services, Inc. 2002. Mini shear study. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TAR Project 455. 16 pp. Internet website: http://www.boemre.gov/tarprojects/455/Final%20Report.pdf.

West Engineering Services, Inc. 2004. Shear ram capability study. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TAR Project 463. Internet website: http://www.boemre.gov/tarprojects/463/(463)%20West%20Engineering%20Final%20Report.pdf.

West Engineering Services, Inc. 2006. Assess the acceptability and safety of using equipment, particularly BOP and wellhead components, at pressures in excess of rated working pressure. Prepared for the U.S. Dept. of the Interior, Minerals Management Service. TAR Project 566. 56 pp. Internet website: http://www.boemre.gov/tarprojects/566/566AA.pdf.

Wetherell, V. 1992. St. Joseph Bay Aquatic Preserve management plan: Adopted January 22, 1992. Florida Dept. of Natural Resources and Bureau of Submerged Lands and Preserves Division of State Lands.

Wheeler, N.M., S.B. Reid, K.J. Craig, J.R. Zielonka, D.R. Stauffer, and S.R. Hanna. 2008. Cumulative increment analysis for the Breton National Wilderness Area. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-058.

White, D. 2010. Personal communication. Marsh health in areas visited after the *Deepwater Horizon* spill. Professor of Biological Sciences, Marsh Ecologist, Tulane University, New Orleans, LA.

White, I.C. and J.M. Baker. 1999. The *Sea Empress* oil spill in context. International Conference on the *Sea Empress* Oil Spill, 11-13th February 1998, Cardiff, Wales.

White, D.H., C.A. Mitchell, H.D. Kennedy, A.J. Krynitsky, and M.A. Ribick. 1983. Elevated DDE and toxaphene residues in fishes and birds reflect local contamination in the lower Rio Grande Valley, Texas. The Southwestern Naturalist 28(3):325-333.

White House Press Briefing. 2010. Press briefing by Press Secretary Robert Gibbs and National Incident Commander Thad Allen (July 1, 2010). Internet website: http://www.whitehouse.gov/the-press-

office/press-briefing-press-secretary-robert-gibbs-and-national-incident-commander-thad-al. Accessed July 8, 2010.

Whittle, K.J., R. Hardy, P.R. Mackie, and A.S. McGill. 1982. A quantitative assessment of the sources and fate of petroleum compounds in the marine environment. Philosophical Transactions of the Royal Society of London. B. 297:193-218.

Wicker, K.M., R.E. Emmer, D. Roberts, and J. van Beek. 1989. Pipelines, navigation channels, and facilities in sensitive coastal habitats: An analysis of Outer Continental Shelf impacts, Coastal Gulf of Mexico. Volume I: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0051. 470 pp.

Wiese, F.K., W.A. Montevecchi, G.K. Davoren, F. Huettmann, A.W. Diamond, and J. Linke. 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Marine Pollution Bulletin 42:1285-1290.

WikiHow. 2010. The how to manual. How to calculate the distance to the horizon. Internet website. http://www.wikihow.com/Calculate-the-Distance-to-the-Horizon. Updated September 29, 2010. Accessed December 30, 2010.

Wikipedia, The Free Encyclopedia. 2010. Offshore oil and gas in the US Gulf of Mexico. Internet website: http://en.wikipedia.org/wiki/Offshore_oil_and_gas_in_the_US_Gulf_of_Mexico. Accessed November 16, 2010.

Wilber, D.H., W. Brostoff, D.G. Clarke, and G.L. Ray. 2005. Sedimentation: Potential biological effects from dredging operations in estuarine and marine environments. DOER Technical Notes Collection. ERDC TN-DOER-E20. U.S. Dept. of the Army, Engineer Research and Development Center, Vicksburg, MS.

Wilber, D.H., G.L. Ray, D.G. Clarke, and R.J. Diaz. 2008. Responses of benthic infauna to large-scale sediment disturbance in Corpus Christi Bay, Texas. Journal of Experimental Marine Biology and Ecology 365:13-22.

Wilhelm, S.I., G.J. Robertson, P.C. Ryan, and D.C. Schneider. 2007. Comparing an estimate of seabirds at risk to a mortality estimate from the November 2004 *Terra Nova* FPSO oil spill. Marine Pollution Bulletin 54:537-544.

Wilkinson, A. 2011. Seafood at risk: Dispersed oil poses a long-term threat. Scientific American. Internet website: http://www.scientificamerican.com/blog/post.cfm?id=seafood-at-risk-dispersed-oil-poses-2011-04-20. Posted April 20, 2011. Accessed May 2, 2011.

Wilkinson, E., L. Branch, and D.L. Miller. 2009. Connectivity of beach mouse habitat in hurricane impacted landscapes: The influence of predation risk, gap width, patch quality, and landscape context on gap crossing probability. 94th Endangered Species Act Annual Meeting, Albuquerque Convention Center, August 2-7, 2009, Albuquerque, NM.

Williams, J.H. and I.W. Duedall. 1997. Florida hurricanes and tropical storms; revised edition. Gainesville, FL: The University of Florida Press. 146 pp.

Wilson, D.L., J.N. Fanjoy, and R.S. Billings. 2004. Gulfwide emission inventory study for the regional haze and ozone modeling efforts: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study 2004-072. 273 pp.

Wilson, D.L., R. Billings, R. Oommen, and R. Chang. 2007. Year 2005 Gulfwide emission inventory study. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-067. 149 pp.

Wilson, D.L., R, Billing, R. Oommen, and B. Lange. 2010. Year 2008 Gulfwide emission inventory study. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2010-045.

Winge, O. 1923. The Sargasso Sea, its boundaries and vegetation. Rep. Dan. Oceanog. Expd, 1908-1910. 3 Misc. Pap. 2:1-34

Wolfe, S.H., J.A. Reidenauer, and D.B. Means. 1988. An ecological characterization of the Florida Panhandle. U.S. Dept. of the Interior, Fish and Wildlife Service Biological Report 88(12) and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 88-0063. 278 pp.

Woods & Poole Economics, Inc. 2006. The 2006 complete economic and demographic data source (CEDDS) on CD-ROM.

Woods & Poole Economics, Inc. 2010. The 2011 complete economic and demographic data source (CEDDS) on CD-ROM.

Wooley, C.M. 1985. Evaluation of morphometric characters used in taxonomic separation of Gulf of Mexico sturgeon, *Acipenser oxyrynchus desotoi*. In: Binkowski, F.P. and S.I. Doroshov, eds. North American sturgeons: Biology and aquaculture potential. Developments in Environmental Biology of Fishes 6. Junk, Dordrecht, The Netherlands. 163 pp.

Wooley, C.M. and E.J. Crateau. 1985. Movement, microhabitat, exploitation and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. North American Journal of Fisheries Management 16:590-605.

Wright, D.G. and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Canadian Technical Report of Fisheries and Aquatic Sciences 2107.

Wu, S.-Y., B. Yarnal, and A. Fisher. 2002. Vulnerability of coastal communities to sea-level rise: A case study of Cape May County, New Jersey. Climate Research 22:255–270.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station: Texas A&M University Press. 232 pp.

Wyers, S.C., H.R. Frith, R.E. Dodge, S.R. Smith, A.H. Knap, and T.D. Sleeter. 1986. Behavioral effects of chemically dispersed oil and subsequent recovery in *Diploria strigosa*. Marine Ecology 7:23-42.

Yarwood, G., G. Mansell, M. Jimenez, and S. Lau. 2004. 2000 Gulf-wide emissions inventory—OCS on-shore impacts modeling (Texas), a preliminary look. Prepared for the U.S. Dept. of the Interior, Minerals Management Service, New Orleans, LA. Novato, CA: ENVIRON International Corporation. September 1, 2004.

Yender, R.A. and Michel, J., eds. 2010. Oil spills in coral reefs: Planning and response considerations. Second edition. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. 82 pp. Internet website: http://response.restoration.noaa.gov/book_shelf/70_coral_full_report.pdf.

Yoshioka, P.M. and B.B. Yoshioka. 1987. Variable effects of Hurricane David on the shallow water gorgonians of Puerto Rico. Bulletin of Marine Science 40(1):132-144.

Zabala, J., I. Zuberogoitia, J.A. Martinez-Climent, and J. Etxezarreta. 2010. Do long lived seabirds reduce the negative effects of acute pollution on adult survival by skipping breeding? A study with European storm petrels (*Hydrobates pelagicus*) during the "Prestige" oil-spill. Marine Pollution Bulletin 62:109-115.

Zabarenko, D. 2010. Special report: Watching grass grow in the Gulf and cheering! News Daily Environmental Correspondent. July 7, 2010. Interview with Dr. Mendelssohn. Wetlands Ecologist, Louisiana State University. Internet website: http://www.reuters.com/article/idUSTRE66R4Z420100728. Accessed December 27, 2010.

Zeller, T., Jr. 2010. Drill ban means hard times for rig workers. *The New York Times*. Internet website: http://www.nytimes.com/2010/06/18/business/18rig.html?_r=1. Accessed June 29, 2010.

Zenz House, K., D.P. Schrag, C.F. Harvey, and K.A. Lackner. 2006. Permanent carbon dioxide storage in deep-sea sediments. Proceedings of the National Academy of Sciences 103(33):12291-12295.

Zhang, Z. and D. McConnell. 2011. Rock physics modeling of the gas hydrate and free gas mixed system in Green Canyon 955, Gulf of Mexico, and implications for gas hydrate prospecting. U.S Dept. of Energy, National Energy Technology Laboratory, Fire in the Ice, January 2011. Pp. 15-19. Internet website: http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/newsletter/newsletter.htm. Accessed March 18, 2011.

Zieman, J.C. 1976. The ecological effects of physical damage from motor boats on turtle grass beds in Southern Florida. Aquatic Botany 2:127-139.

Zieman, J.C. 1982. The ecology of the seagrasses of south Florida: A community profile. U.S. Dept. of the Interior, Fish and Wildlife Service. FWS/OBS-82/25. 123 pp.

Zieman, J.C. and R.T. Zieman. 1989. The ecology of the seagrass meadows of the west coast of Florida: A community profile. U.S. Dept. of the Interior, Fish and Wildlife Service. Biological Report 85(7.25). 155 pp.

Zieman, J.C., R. Orth, R.C. Phillips, G. Thayer, and A. Thorhaug. 1984. The effects of oil on seagrass ecosystems. In: Cairns, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers.

Zuberogoitia, I., J.A. Martinez, A. Iraeta, A. Azkona, J. Zabala, B. Jimenez, R. Merino, and G. Gomez. 2006. Short-term effects of the *Prestige* oil spill on the peregrine falcon (*Falco peregrinus*). Marine Pollution Bulletin 52:1176-1181.

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CHAPTER 8

GLOSSARY

8. GLOSSARY

Acute — Sudden, short term, severe, critical, crucial, intense, but usually of short duration.

Anaerobic — Capable of growing in the absence of molecular oxygen.

Annular preventer — A component of the pressure control system in the BOP that forms a seal in the annular space around any object in the wellbore or upon itself, enabling well control operations to commence.

Anthropogenic — Coming from human sources, relating to the effect of humankind on nature.

API gravity — A standard adopted by the American Petroleum Institute for expressing the specific weight of oil.

Aromatic — Class of organic compounds containing benzene rings or benzenoid structures.

Attainment area — An area that is shown by monitored data or by air-quality modeling calculations to be in compliance with primary and secondary ambient air quality standards established by the USEPA.

Barrel (bbl) — A volumetric unit used in the petroleum industry; equivalent to 42 U.S. gallons or 158.99 liters.

Benthic — On or in the bottom of the sea.

Biological Opinion — The FWS or NMFS evaluation of the impact of a proposed action on endangered and threatened species, in response to formal consultation under Section 7 or the endangered Species Act.

Block — A geographical area portrayed on official BOEMRE protraction diagrams or leasing maps that contains approximately 2,331 ha (9 mi^2).

Blowout — An uncontrolled flow of fluids below the mudline from appurtenances on a wellhead or from a wellbore.

Blowout preventer (BOP) — One of several valves installed at the wellhead to prevent the escape of pressure either in the annular space between the casing and drill pipe or in open hole (i.e., hole with no drill pipe) during drilling completion operations. Blowout preventers on jackup or platform rigs are located at the water's surface; on floating offshore rigs, BOP's are located on the seafloor.

Bottom kill — A wild well-control procedure involving the intersection of an uncontrolled well with a relief well for the purpose of pumping heavy mud or cement into the wild well to stanch the flow of oil or gas (the well control strategy for the Macondo spill deployed in mid-July 2010 that resulted in the successful capping of the well.

Cetacean — Aquatic mammal of the order Cetacea, such as whales, dolphins, and porpoises.

Chemosynthetic — Organisms that obtain their energy from the oxidation of various inorganic compounds rather than from light (photosynthetic).

Cofferdam containment dome — A vertically elongated box structure designed to fit loosely over the Macondo lower marine riser package to capture escaping oil at the surface (an early containment strategy for the Macondo spill deployed in May 2010).

Coastal waters — Waters within the geographical areas defined by each State's Coastal Zone Management Program.

Coastal wetlands — forested and nonforested habitats, mangroves, and marsh islands exposed to tidal activity. These areas directly contribute to the high biological productivity of coastal waters by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, and by serving as habitat for birds and other animals.

Coastal zone — The coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder) strongly influenced by each other and in proximity to the shorelines of the several coastal states; the zone includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches and extends seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are

lands the use of which is by law subject to the discretion of or which is held in trust by the Federal Government, its officers, or agents. See also State coastal zone boundaries.

Completion — Conversion of a development well or an exploratory well into a production well.

Condensate — Liquid hydrocarbons produced with natural gas; they are separated from the gas by cooling and various other means. Condensates generally have an API gravity of 50^{o}-120^{o}.

Continental margin — The ocean floor that lies between the shoreline and the abyssal ocean floor, includes the continental shelf, continental slope, and continental rise.

Continental shelf — General term used by geologist to refer to the continental margin province that lies between the shoreline and the abrupt change in slope called the shelf edge, which generally occurs in the Gulf of Mexico at about 200 m water depth. The continental shelf is characterized by a gentle slope (about 0.1^{o}). This is different from the juridicial term used in Article 76 of the Convention on the Law of the Sea (see the definition of Outer Continental Shelf).

Continental slope — The continental margin province that lies between the continental shelf and continental rise, characterized by a steep slope (about 3^{o}-6^{o}).

Critical habitat — Specific areas essential to the conservation of a protected species and that may require special management considerations or protection.

Crude oil — Petroleum in its natural state as it emerges from a well, or after it passes through a gas-oil separator but before refining or distillation. An oily, flammable, bituminous liquid that is essentially a complex mixture of hydrocarbons of different types with small amounts of other substances.

Deferral — Action taken by the Secretary of the Interior at the time of the Area Identification to remove certain areas/blocks from the proposed sale.

Delineation well — A well that is drilled for the purpose of determining the size and/or volume of an oil or gas reservoir.

Demersal — Living at or near the bottom of the sea.

***Deepwater Horizon* (DWH) event** — All actions stemming from the April 20, 2010, explosion and subsequent sinking of the Transocean drillship *Deepwater Horizon*, up to and including the Macondo well kill declaration on September 19, 2010.

Development — Activities that take place following discovery of economically recoverable mineral resources, including geophysical surveying, drilling, platform construction, operation of onshore support facilities, and other activities that are for the purpose of ultimately producing the resources.

Development Operations Coordination Document (DOCD) — A document that must be prepared by the operator and submitted to BOEMRE for approval before any development or production activities are conducted on a lease in the Western Gulf.

Development well — A well drilled to a known producing formation to extract oil or gas; a production well; distinguished from a wildcat or exploratory well and from an offset well.

Direct employment — Consists of those workers involved the primary industries of oil and gas exploration, development, and production operations (Standard Industrial Classification Code 13—Oil and Gas Extraction).

Discharge — Something that is emitted; flow rate of a fluid at a given instant expressed as volume per unit of time.

Dispersant — A suite of chemicals and solvents used to break up an oil slick into small droplets, which increases the surface area of the oil and hastens the processes of weathering and microbial degradation.

Dispersion — A suspension of finely divided particles in a medium.

Drilling mud — A mixture of clay, water or refined oil, and chemical additives pumped continuously downhole through the drill pipe and drill bit, and back up the annulus between the pipe and the walls of the borehole to a surface pit or tank. The mud lubricates and cools the drill bit, lubricates the drill pipe as it turns in the wellbore, carries rock cuttings to the surface, serves to keep the hole from crumbling or collapsing, and provides the weight or hydrostatic head to prevent extraneous fluids from entering the well bore

and to downhole pressures; also called drilling fluid.

Economically recoverable resources — An assessment of hydrocarbon potential that takes into account the physical and technological constraints on production and the influence of costs of exploration and development and market price on industry investment in OCS exploration and production.

Effluent — The liquid waste of sewage and industrial processing.

Effluent limitations — Any restriction established by a State or the USEPA on quantities, rates, and concentrations of chemical, physical, biological, and other constituents discharged from point sources into U.S. waters, including schedules of compliance.

Epifaunal — Animals living on the surface of hard substrate.

Essential habitat — Specific areas crucial to the conservation of a species and that may necessitate special considerations.

Estuary — Coastal semienclosed body of water that has a free connection with the open sea and where freshwater meets and mixes with seawater.

Eutrophication — Enrichment of nutrients in the water column by natural or artificial methods accompanied by an increase of respiration, which may create an oxygen deficiency.

Exclusive Economic Zone (EEZ) — The maritime region extending 200 nmi from the baseline of the territorial sea, in which the United States has exclusive rights and jurisdiction over living and nonliving natural resources.

Exploration Plan (EP) — A plan that must be prepared by the operator and submitted to BOEMRE for approval before any exploration or delineation drilling is conducted on a lease in the Western Gulf.

Exploration well — A well drilled in unproven or semi-proven territory to determining whether economic quantities of oil or natural gas deposit are present; exploratory well.

False crawls — Refers to when a female sea turtle crawls up on the beach to nest (perhaps) but does not and returns to the sea without laying eggs.

Field — An accumulation, pool, or group of pools of hydrocarbons in the subsurface. A hydrocarbon field consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.

Floating production, storage, and offloading (FPSO) system — A tank vessel used as a production and storage base; produced oil is stored in the hull and periodically offloaded to a shuttle tanker for transport to shore..

Gathering lines — A pipeline system used to bring oil or gas production from a number of separate wells or production facilities to a central trunk pipeline, storage facility, or processing terminal.

Geochemical — Of or relating to the science dealing with the chemical composition of and the actual or possible chemical changes in the crust of the earth.

Geophysical survey — A method of exploration in which geophysical properties and relationships are measured remotely by one or more geophysical methods.

Habitat — A specific type of environment that is occupied by an organism, a population, or a community.

Hermatypic coral — Reef-building corals that produce hard, calcium carbonate skeletons and that possess symbiotic, unicellular algae within their tissues.

Harassment — An intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, feeding or sheltering.

Hydrocarbons — Any of a large class of organic compounds containing primarily carbon and hydrogen. Hydrocarbon compounds are divided into two broad classes: aromatic and aliphatics. They occur primarily in petroleum, natural gas, coal, and bitumens.

Hypoxia — Depressed levels of dissolved oxygen in water, usually resulting in decreased metabolism.

Incidental take — Takings that result from, but are not the purpose of, carrying out an

otherwise lawful activity (e.g., fishing) conducted by a Federal agency or applicant (see Taking).

Indirect employment — Secondary or supporting oil- and gas-related industries, such as the processing of crude oil and gas in refineries, natural gas plants, and petrochemical plants.

Induced employment — Tertiary industries that are created or supported by the expenditures of employees in the primary or secondary industries (direct and indirect employment), including consumer goods and services such as food, clothing, housing, and entertainment.

Infrastructure — The facilities associated with oil and gas development, e.g., refineries, gas processing plants, etc.

Jack-up rig — A barge-like, floating platform with legs at each corner that can be lowered to the sea bottom to raise the platform above the water.

Junk shot — A wild well-control procedure accompanying a top kill that introduces foreign objects into the drilling fluid (such as shredded rope, rubber, or golf balls) and that is designed to clog the openings or partial openings in a nonfunctioning blowout preventer (an early well control strategy for the Macondo spill in May 2010).

Kick — A deviation or imbalance, typically sudden or unexpected, between the downward pressure exerted by the drilling fluid and the upward pressure of in situ formation fluids or gases.

Landfall — The site where a marine pipeline comes to shore.

Lease — Authorization that is issued under Section 8 or maintained under Section 6 of the Outer Continental Shelf Lands Act and that authorizes exploration for, and development and production of, minerals.

Lease sale — The competitive auction of leases granting companies or individuals the right to explore for and develop certain minerals under specified conditions and periods of time.

Lease term — The initial period for oil and gas leases, usually a period of 5, 8, or 10 years depending on water depth or potentially adverse conditions.

Lessee — A party authorized by a lease, or an approved assignment thereof, to explore for and develop and produce the leased deposits in accordance with regulations at 30 CFR 250.

Lower marine riser package — The head assembly of a subsurface well at the point where the riser connects to a blowout preventer.

Macondo — Prospect name given by BP to the Mississippi Canyon Block 252 exploration well that the *Deepwater Horizon* rig was drilling when a blowout occurred on April 20, 2010.

Macondo spill — The name given to the oil spill that resulted from the explosion and sinking of the *Deepwater Horizon* rig from the period between April 24, 2010, when search and recovery vessels on site reported oil at the sea surface until uncontrolled flow from the Macondo well was capped.

Marshes — Persistent, emergent, nonforested wetlands characterized by predominantly cordgrasses, rushes, and cattails.

Military warning area — An area established by the Department of Defense within which military activities take place.

Minerals — As used in this document, minerals include oil, gas, sulphur, and associated resources, and all other minerals authorized by an Act of Congress to be produced from public lands as defined in Section 103 of the Federal Land Policy and Management Act of 1976.

Nepheloid — A layer of water near the bottom that contains significant amounts of suspended sediment.

Nonattainment area — An area that is shown by monitoring data or by air-quality modeling calculations to exceed primary or secondary ambient air quality standards established by the USEPA.

Nonhazardous oil-field wastes (NOW) — Wastes generated by exploration, development, or production of crude oil or natural gas that are exempt from hazardous waste regulation under the Resource Conservation and Recovery Act (*Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes,* dated June 29, 1988,

53 FR 25446; July 6, 1988). These wastes may contain hazardous substances.

Naturally occurring radioactive materials (NORM) — naturally occurring material that emits low levels of radioactivity, originating from processes not associated with the recovery of radioactive material. The radionuclides of concern in NORM are Radium-226, Radium-228, and other isotopes in the radioactive decay chains of uranium and thorium.

Offloading — Unloading liquid cargo, crude oil, or refined petroleum products.

Operational discharge — Any incidental pumping, pouring, emitting, emptying, or dumping of wastes generated during routine offshore drilling and production activities.

Operator — An individual, partnership, firm, or corporation having control or management of operations on a leased area or portion thereof. The operator may be a lessee, designated agent of the lessee, or holder of operating rights under an approved operating agreement.

Organic matter — Material derived from living plants or animals.

Outer Continental Shelf (OCS) — All submerged lands that comprise the continental margin adjacent to the United States and seaward of State offshore lands.

Pelagic — Of or pertaining to the open sea; associated with open water beyond the direct influence of coastal systems.

Penaeids — Chiefly warm water and tropical prawns belonging to the family Penaeidae.

Plankton — Passively floating or weakly motile aquatic plants (phytoplankton) and animals (zooplankton).

Platform — A steel or concrete structure from which offshore development wells are drilled.

Play — A prospective subsurface area for hydrocarbon accumulation that is characterized by a particular structural style or depositional relationship.

Primary production — Organic material produced by photosynthetic or chemosynthetic organisms.

Produced water — Total water discharged from the oil and gas extraction process; production water or production brine.

Production — Activities that take place after the successful completion of any means for the extraction of resources, including bringing the resource to the surface, transferring the produced resource to shore, monitoring operations, and drilling additional wells or workovers.

Province — A spatial entity with common geologic attributes. A province may include a single dominant structural element such as a basin or a fold belt, or a number of contiguous related elements.

Ram — The main component of a blowout preventer designed to shear casing and tools in a wellbore or to seal an empty wellbore. A blind shear ram accomplishes the former and a blind ram the latter.

Recoverable reserves — The portion of the identified hydrocarbon or mineral resource that can be economically extracted under current technological constraints.

Recoverable resource estimate — An assessment of hydrocarbon or mineral resources that takes into account the fact that physical and technological constraints dictate that only a portion of resources can be brought to the surface.

Recreational beaches — Frequently visited, sandy areas along the Gulf of Mexico shorefront that support multiple recreational activities at the land-water interface. Included are National Seashores, State Park and Recreational Areas, county and local parks, urban beachfronts, and private resorts.

Refining — Fractional distillation of petroleum, usually followed by other processing (for example, cracking).

Relief — The difference in elevation between the high and low points of a surface.

Reserves — Proved oil or gas resources.

Rig — A structure used for drilling an oil or gas well.

Riser insertion tube tool — A “straw” and gasket assembly improvised during the Macondo spill response that was designed to siphon oil and gas from the broken riser of the *Deepwater*

Horizon lying on the sea bottom (an early recovery strategy for the Macondo spill in May 2010).

Royalty — A share of the minerals produced from a lease paid in either money or "in-kind" to the landowner by the lessee.

Saltwater intrusion — Saltwater invading a body of freshwater.

Sciaenids — Fishes belonging to the croaker family (Sciaenidae).

Seagrass beds — More or less continuous mats of submerged, rooted, marine, flowering vascular plants occurring in shallow tropical and temperate waters. Seagrass beds provide habitat, including breeding and feeding grounds, for adults and/or juveniles of many of the economically important shellfish and finfish.

Sediment — Material that has been transported and deposited by water, wind, glacier, precipitation, or gravity; a mass of deposited material.

Seeps (hydrocarbon) — Gas or oil that reaches the surface along bedding planes, fractures, unconformities, or fault planes.

Sensitive area — An area containing species, populations, communities, or assemblages of living resources, that is susceptible to damage from normal OCS-related activities. Damage includes interference with established ecological relationships.

Shear ram — The component in a BOP that cuts, or shears, through the drill pipe and forms a seal against well pressure. Shear rams are used in floating offshore drilling operations to provide a quick method of moving the rig away from the hole when there is no time to trip the drill stem out of the hole.

Shunting — A method used in offshore oil and gas drilling and production activities where expended cuttings and fluids are discharged through a downpipe, which terminates no more than 10 m from the ocean floor, rather than discharged at the ocean surface.

Shoreline Cleanup and Assessment Team — The on-the-scene responders for post-spill shoreline protection who established priorities, standardized procedures and establish terminology.

Spill of National Significance — Designation by the USEPA Administrator under 40 CFR 300.323 for discharges occurring in the inland zone and the Commandant of the CG for discharges occurring in the coastal zone, authorizing the appointment of a National Incident Commander for spill-response activity.

State coastal zone boundary — The State coastal zone boundaries for each CZMA-affected State are defined at http://coastalmanagement.noaa.gov/mystate/docs/StateCZBoundaries.pdf.

Structure — Any OCS facility that extends from the seafloor to above the waterline; in petroleum geology, any arrangement of rocks that may hold an accumulation of oil or gas.

Subarea — A discrete analysis area.

Subsea isolation device — An emergency disconnection and reconnection assembly for the riser at the seafloor.

Supply vessel — A boat that ferries food, water, fuel, and drilling supplies and equipment to an offshore rig or platform and returns to land with refuse that cannot be disposed of at sea.

Taking — To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any endangered or threatened species, or to attempt to engage in any such conduct (including actions that induce stress, adversely impact critical habitat, or result in adverse secondary or cumulative impacts). Harassments are the most common form of taking associated with OCS Program activities.

Tension-leg platform (TLP) — A production structure that consists of a buoyant platform tethered to concrete pilings on the seafloor with flexible cable.

Top hat — A short cylindrical sleeve with a tapered apex designed to fit atop of the lower marine riser package and to capture oil and gas from the flowing Macondo well (a functional subsurface recovery strategy for the Macondo spill in June and July, before the well was capped on July 15, 2010).

Top kill — A wild well-control procedure involving the pump-down under pressure of heavy drilling fluid to equalize pressure and to stop the flow of gas and oil exiting a blowout

(an early well control strategy for the Macondo spill deployed in May 2010).

Total dissolved solids — The total amount of solids that are dissolved in water.

Total suspended particulate matter — The total amount of suspended solids in water.

Total suspended solids — The total amount of suspended solids in water.

Trunkline — A large-diameter pipeline receiving oil or gas from many smaller tributary gathering lines that serve a large area; common-carrier line; main line.

Turbidity — Reduced water clarity due to the presence of suspended matter.

Unified Area Command — A system of satellite work, coordination, and remediation stations administered by the Unified Incident Commander during a spill of national significance.

Unified Incident Command — Command and coordination center for the National Incident Commander.

Volatile organic compound (VOC) — Any organic compound that is emitted to the atmosphere as a vapor.

Water test areas — Areas within the Eastern Gulf where Department of Defense research, development, and testing of military planes, ships, and weaponry take place.

Weathering (of oil) — The aging of oil due to its exposure to the atmosphere, causing marked alterations in its physical and chemical makeup.

APPENDICES

APPENDIX A

FIGURES AND TABLES

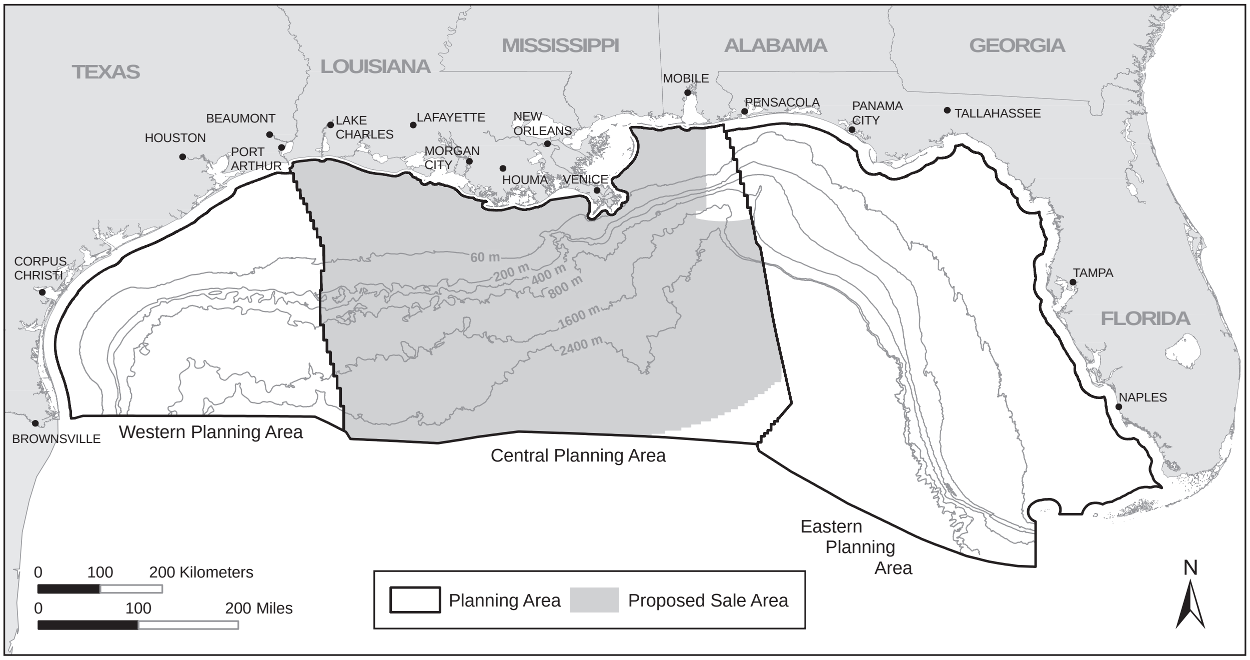

Figure 1-1. Gulf of Mexico Outer Continental Shelf Planning Areas, Proposed Lease Sale Area, and Locations of Major Cities.

Figure 1-2. Location of the Macondo Well in the Gulf of Mexico's Central Planning Area.

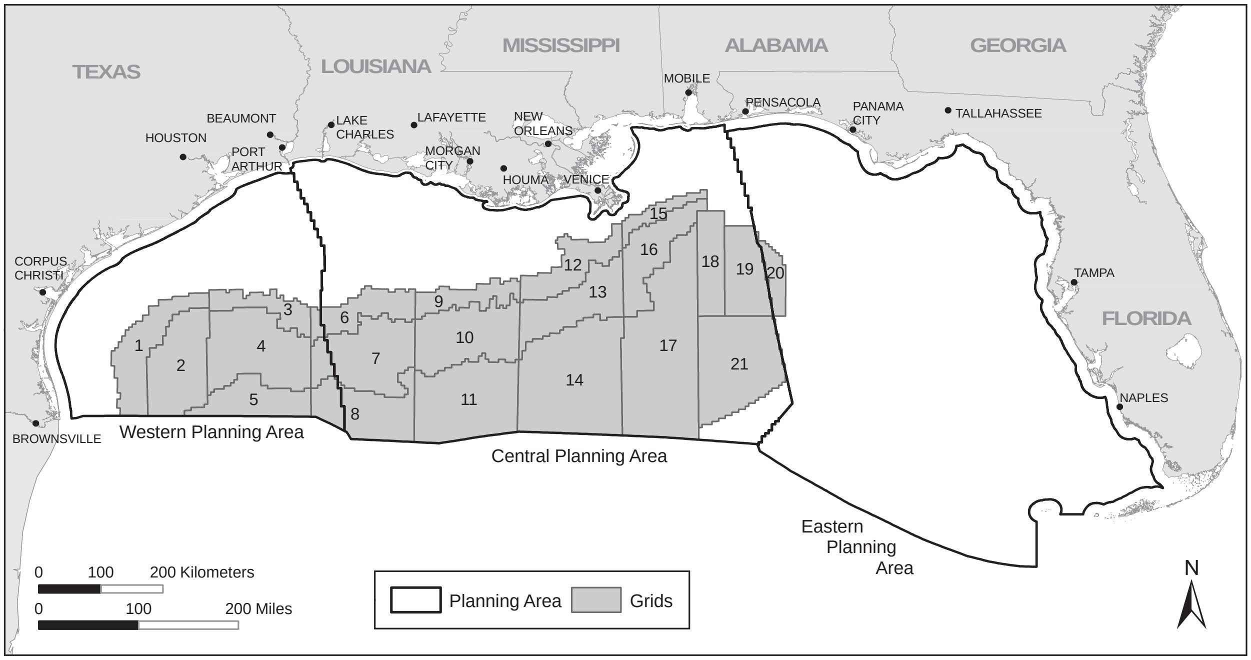

Figure 1-3. Grid Areas of Remotely Operated Vehicle Surveys in Deep Water from NTL 2008-G06.

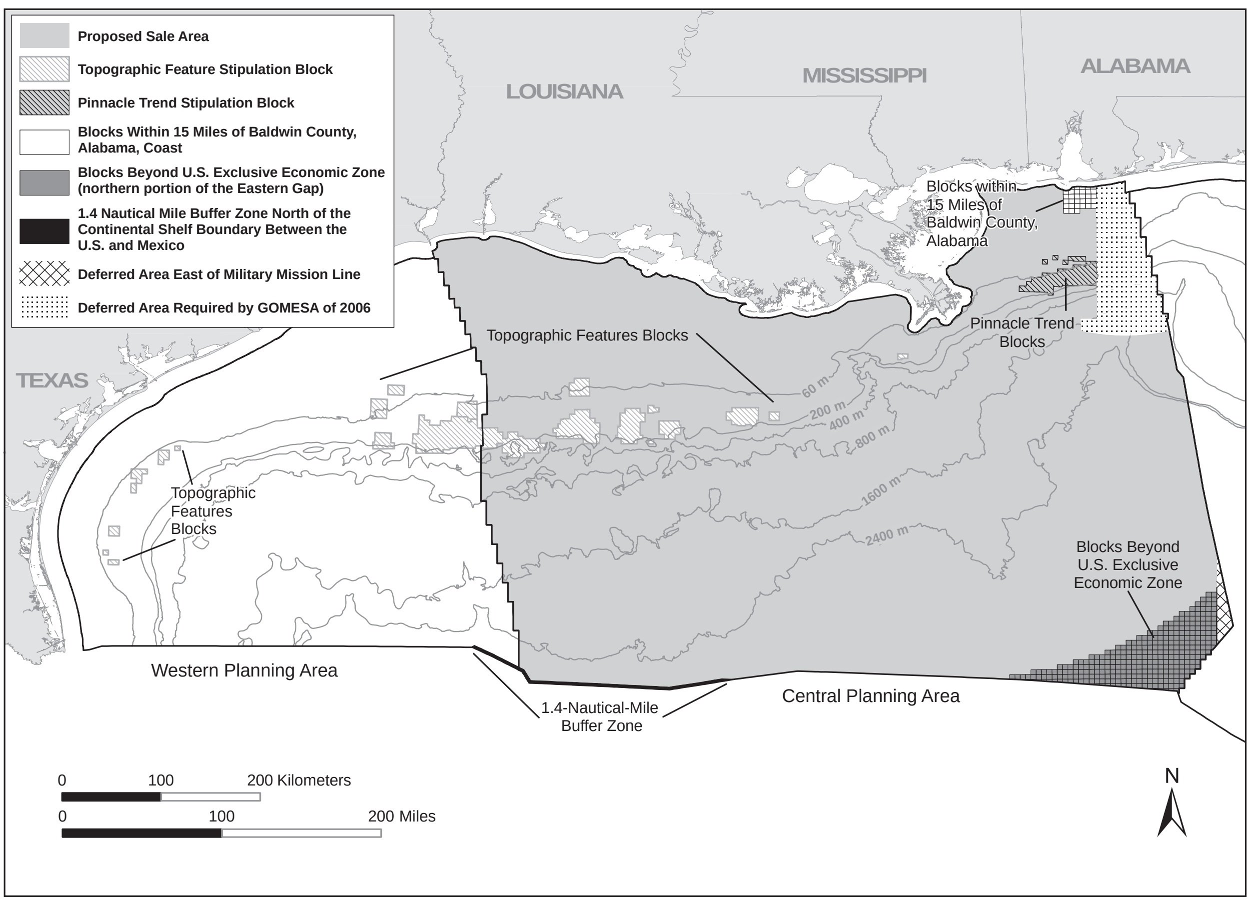

Figure 2-1. Location of Proposed Stipulations and Deferrals.

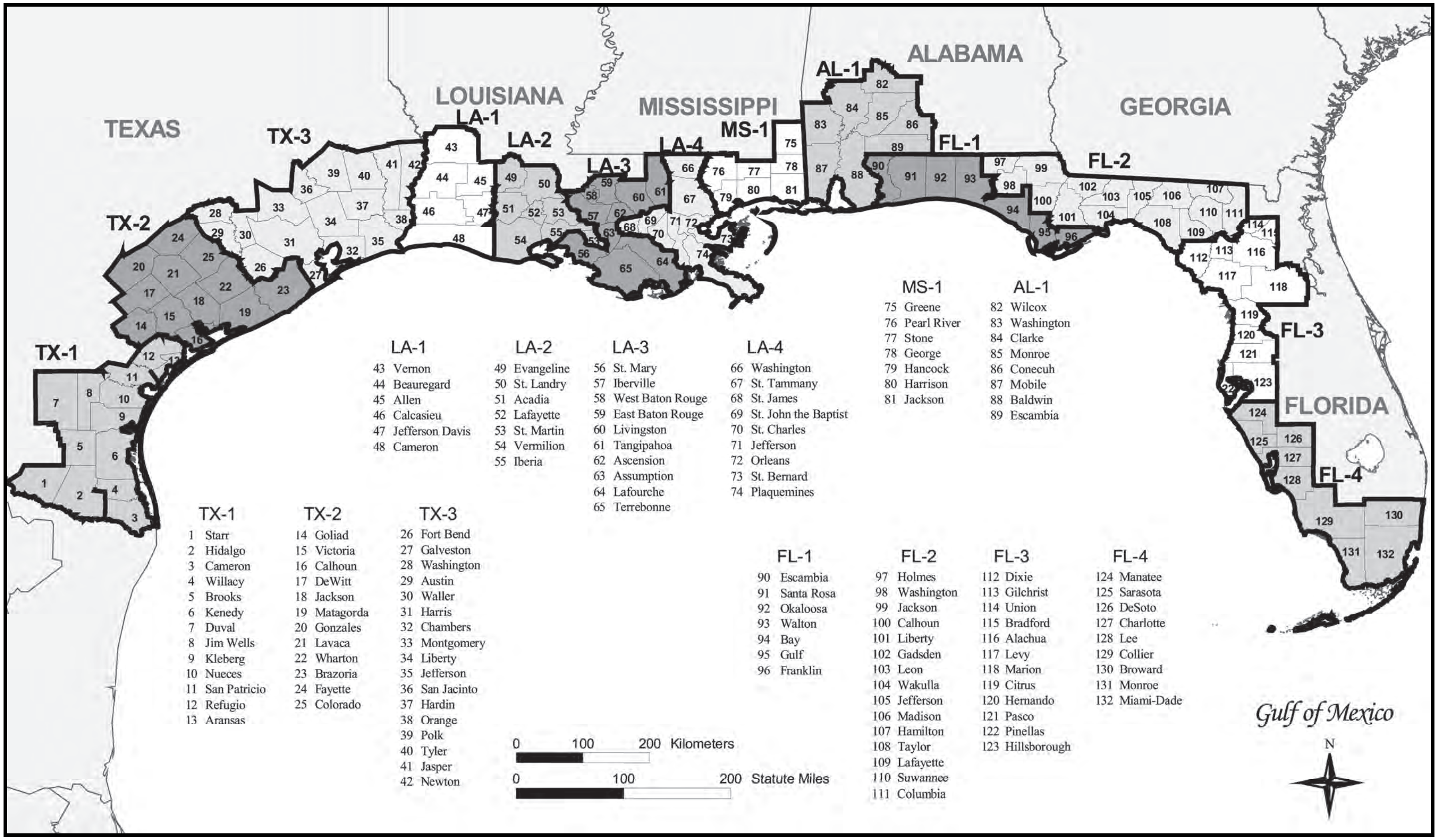

Figure 2-2. Economic Impact Areas in the Gulf of Mexico.

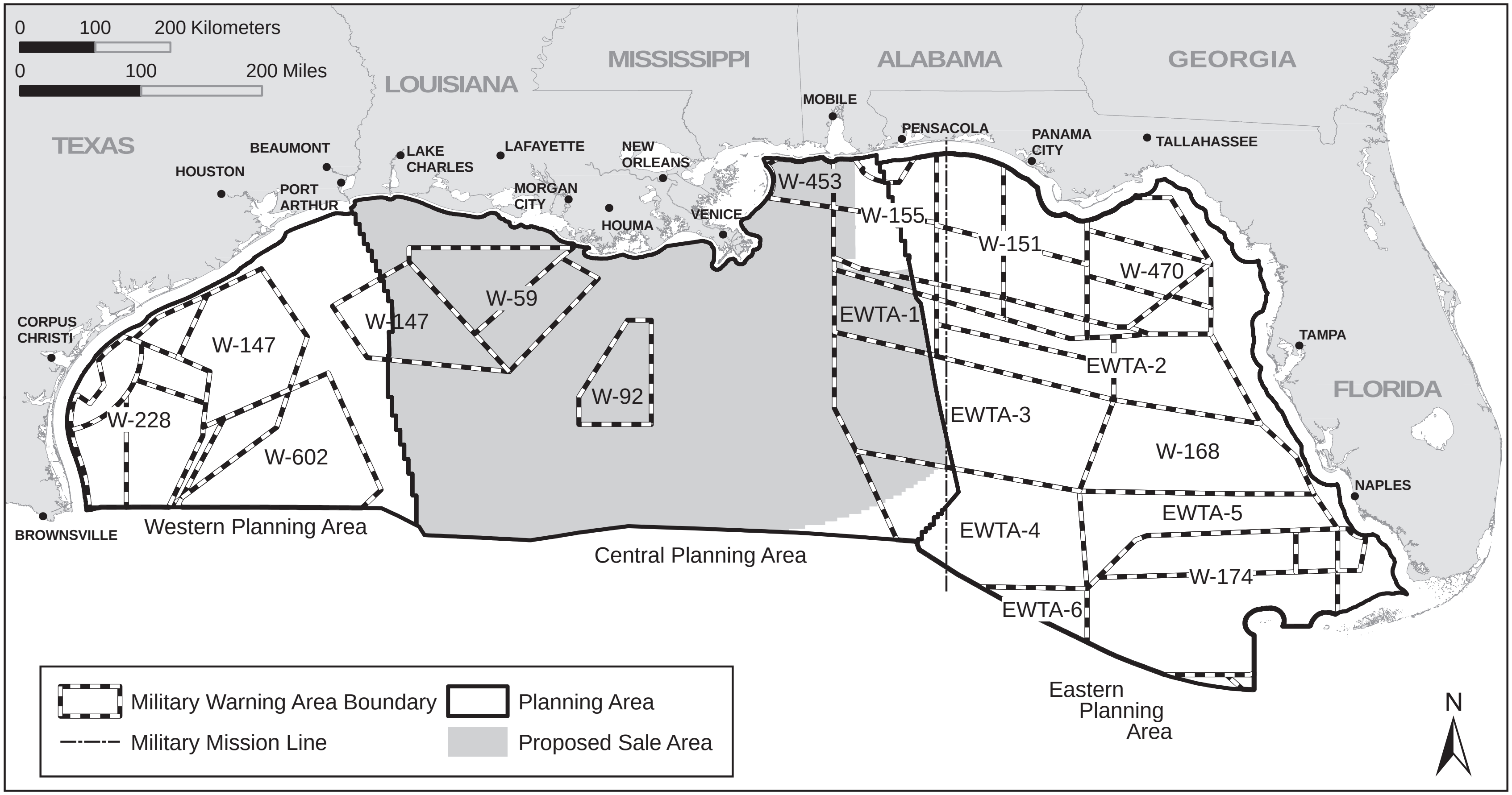

Figure 2-3. Military Warning Areas and Eglin Water Test Areas Located in the Gulf of Mexico.

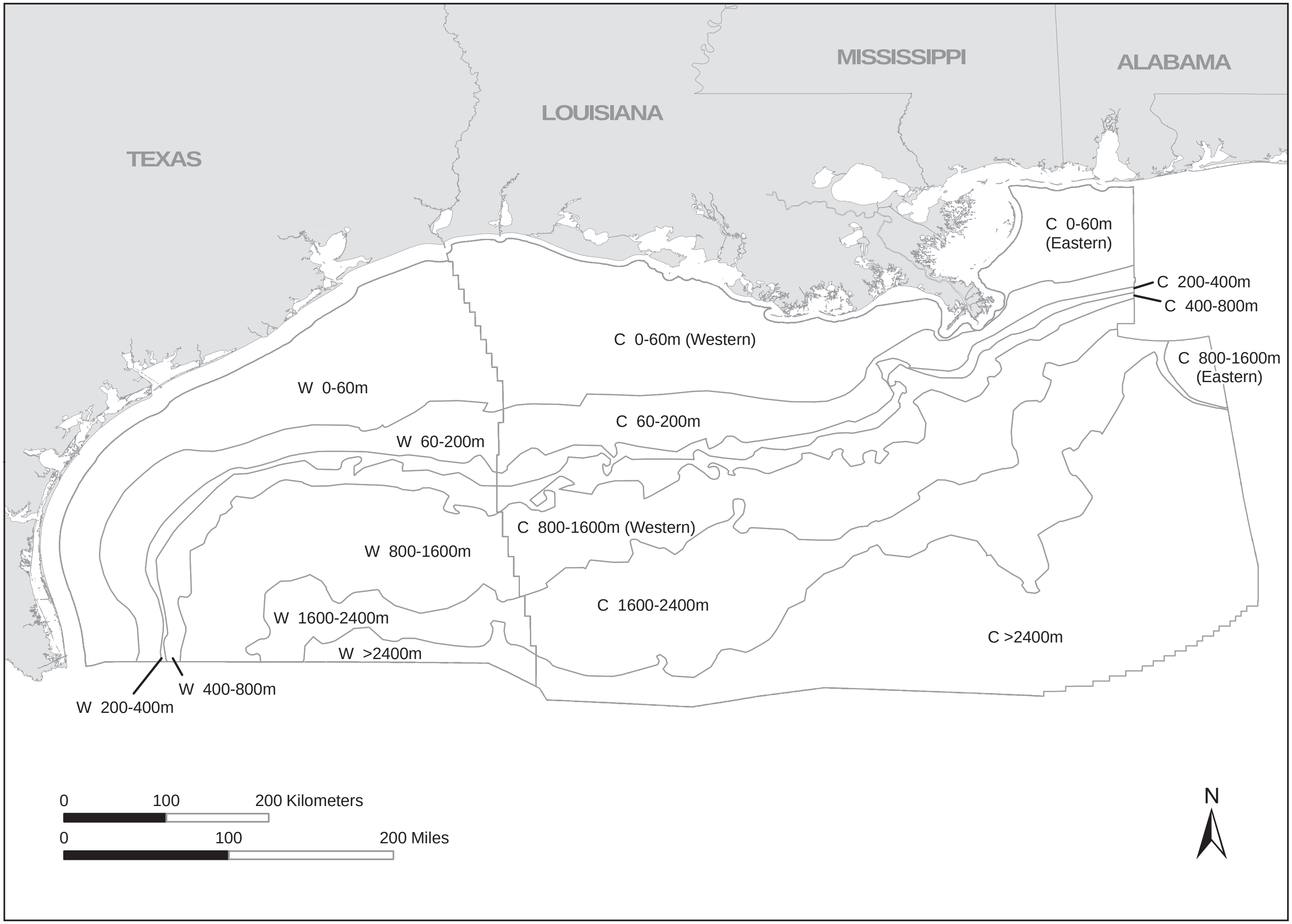

Figure 3-1. Offshore Subareas in the Gulf of Mexico.

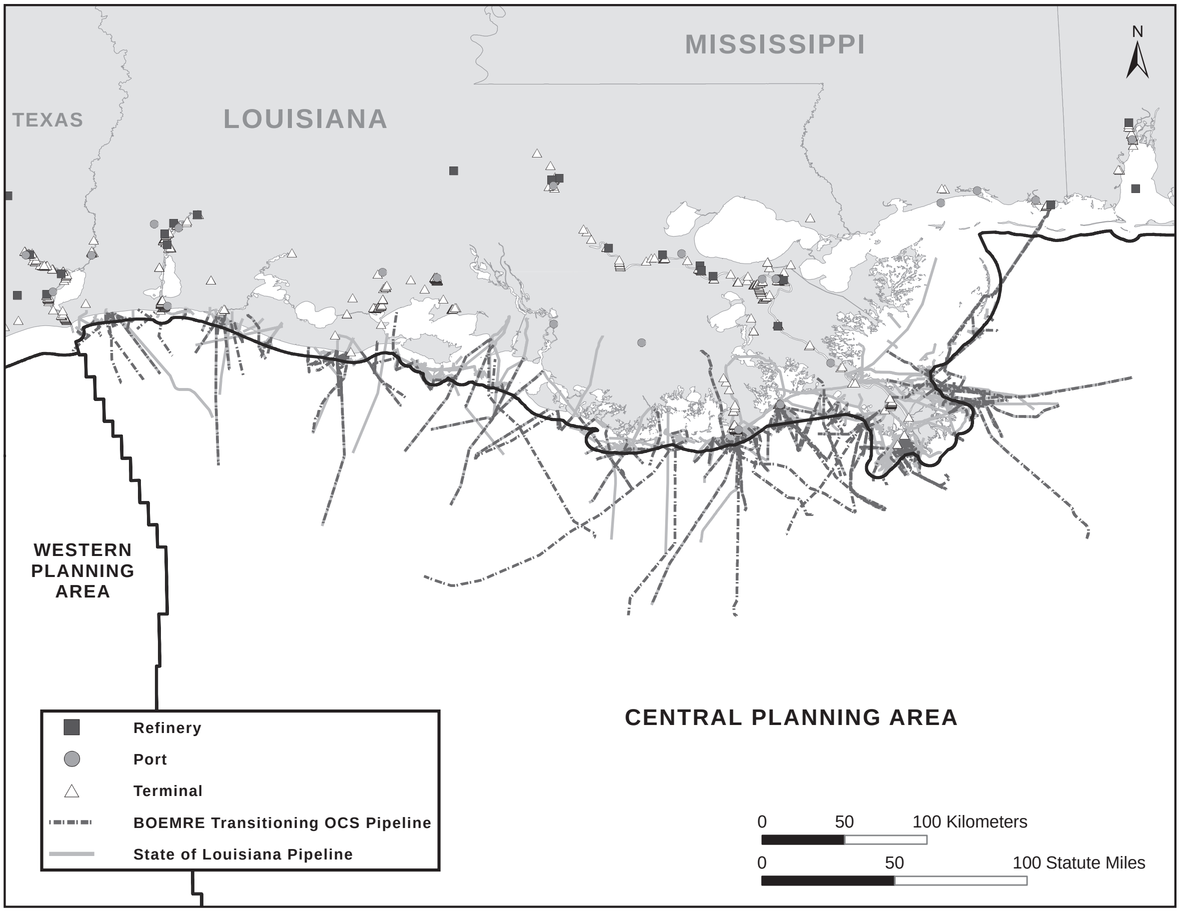

Figure 3-2. Pipelines Transitioning from Federal OCS and Louisiana State Waters.

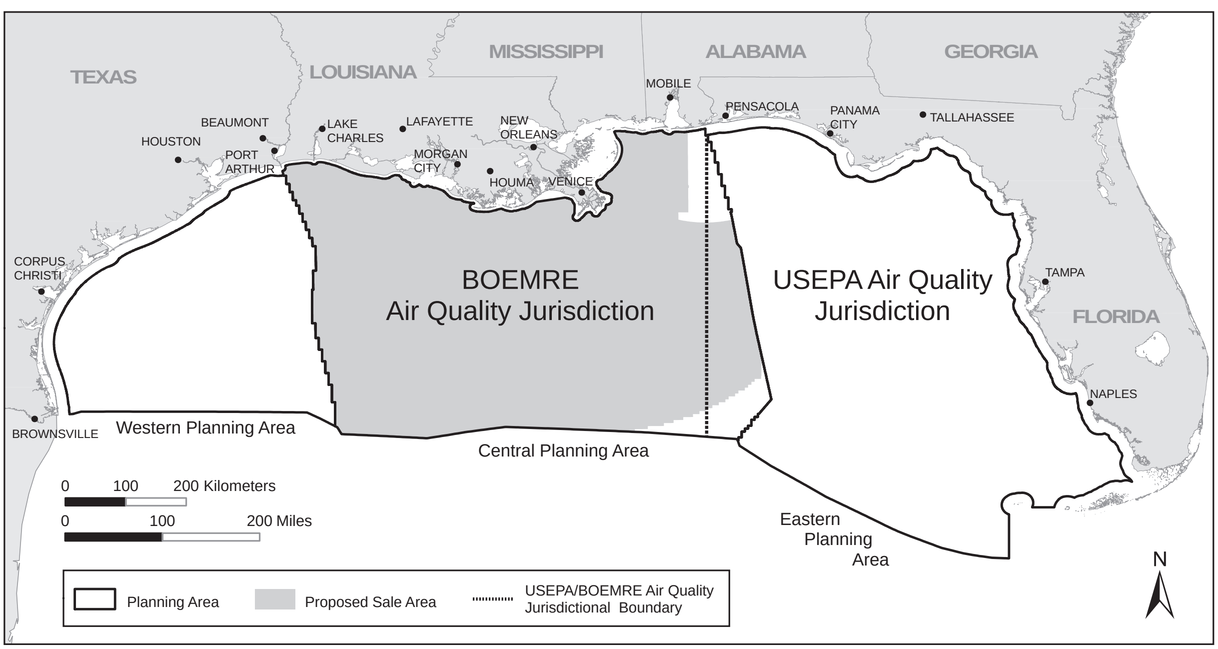

Figure 3-3. Air Quality Jurisdiction.

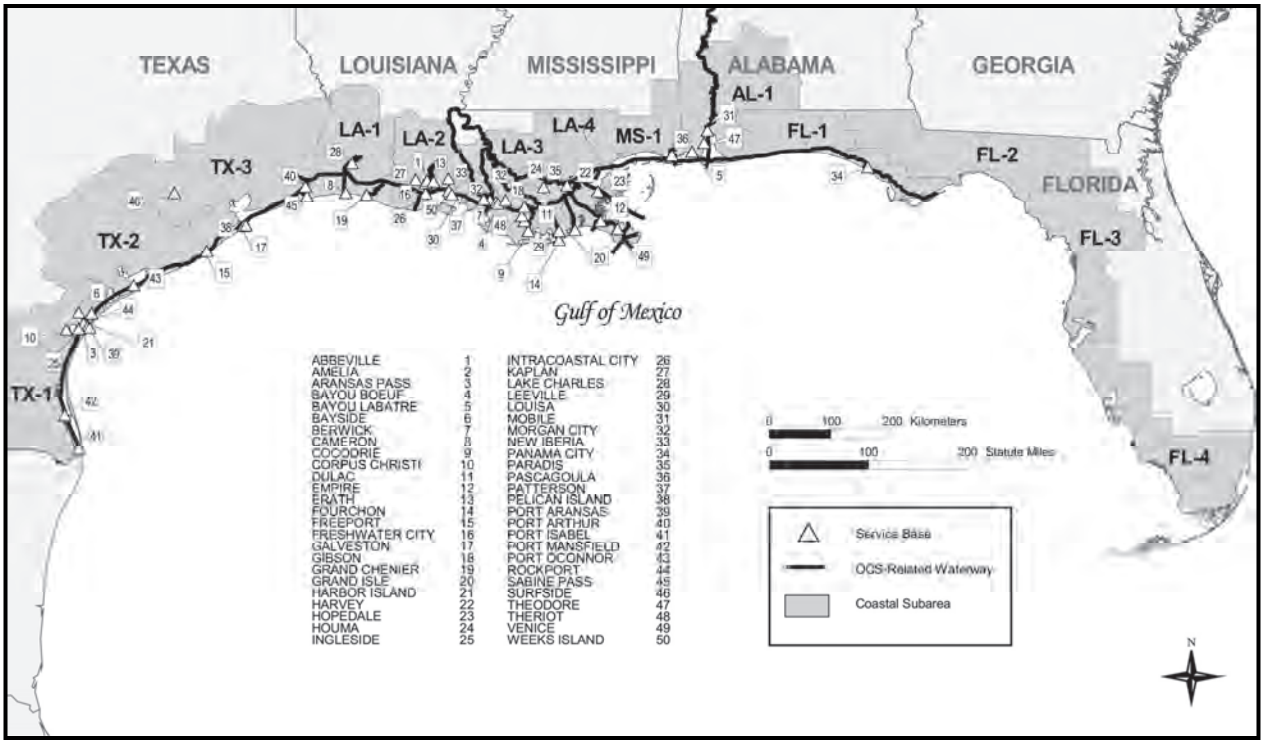

Figure 3-4. OCS-Related Service Bases in the Gulf of Mexico.

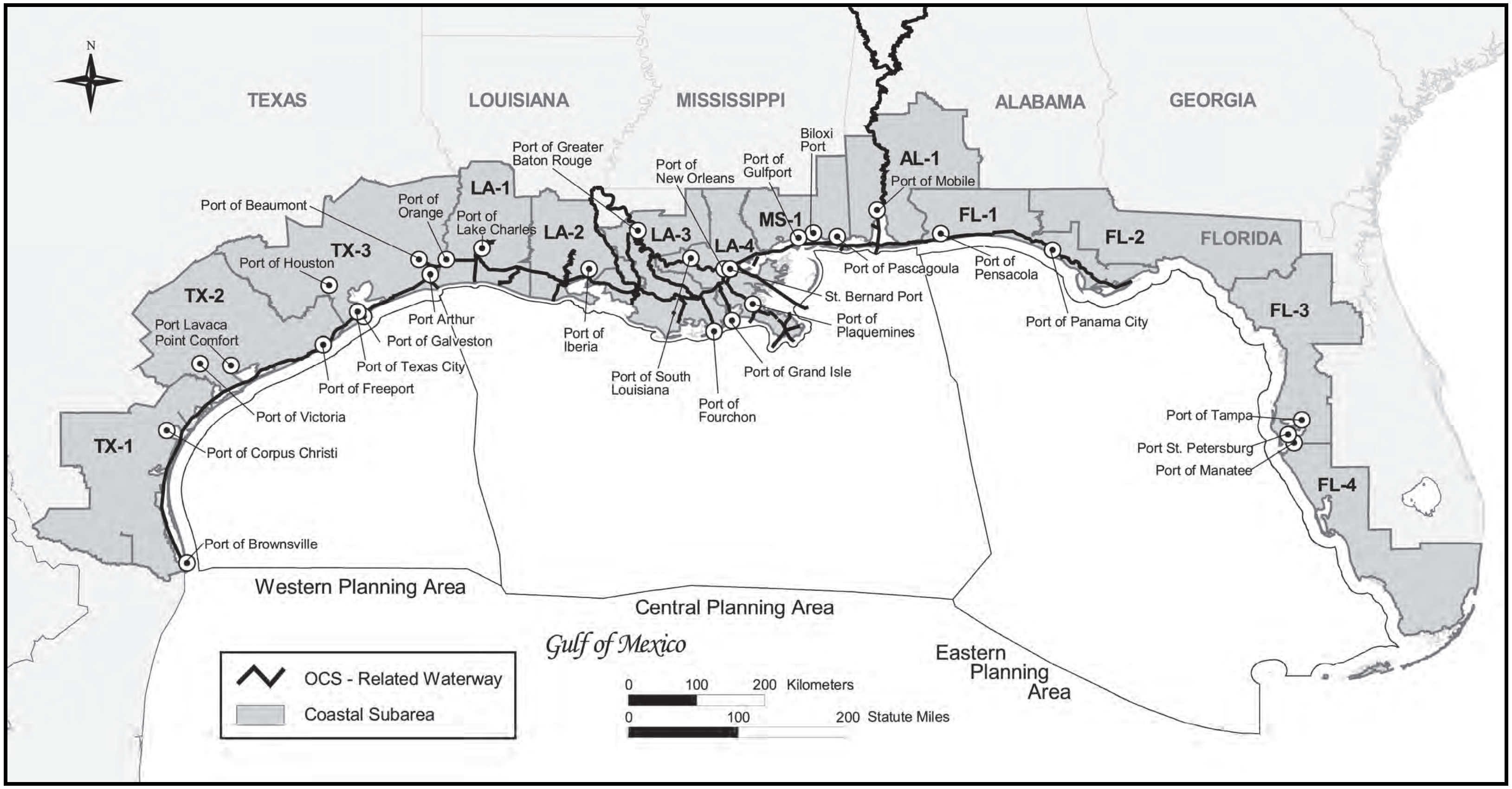

Figure 3-5. Major Ports and Domestic Waterways in the Gulf of Mexico.

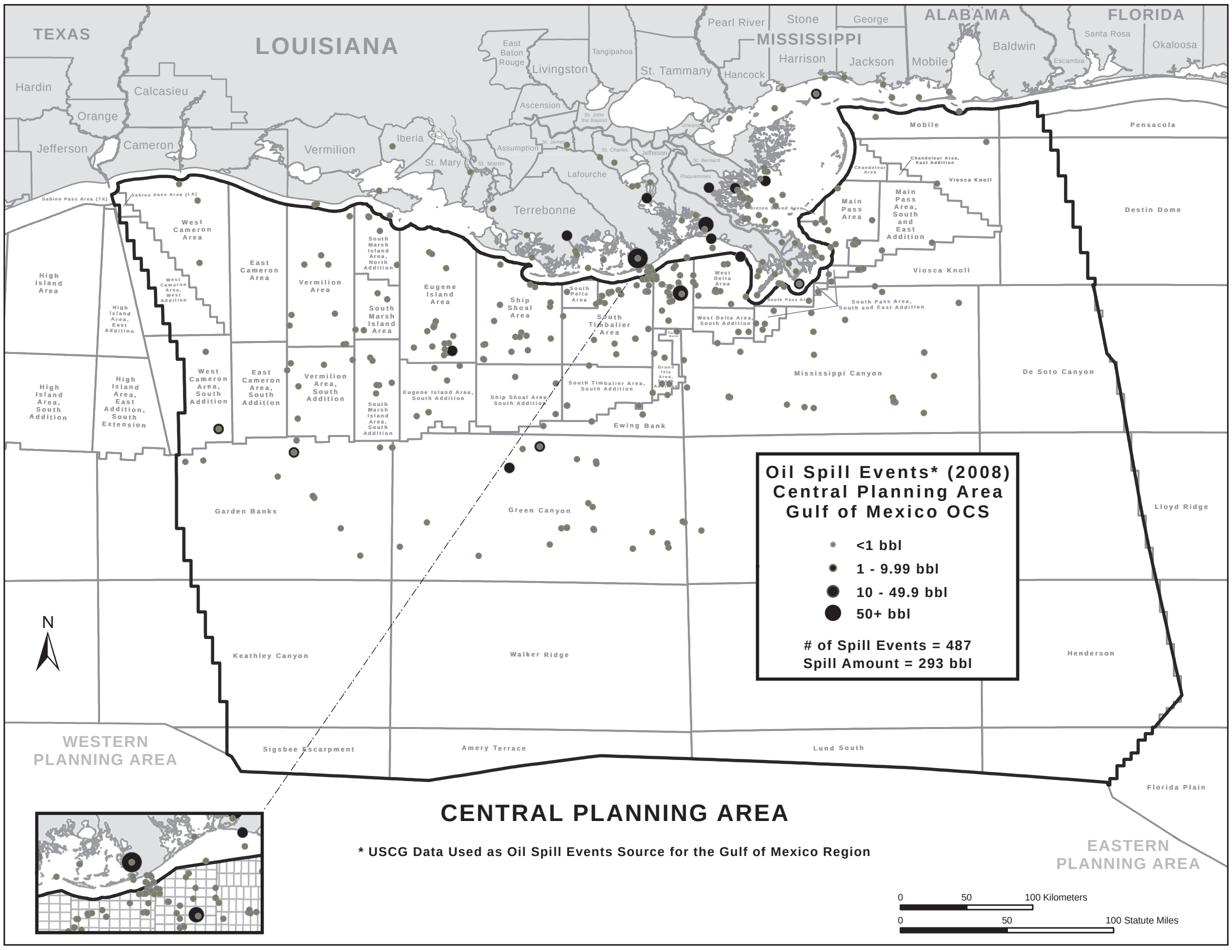

Figure 3-6. Oil-Spill Events (2008) in the Central Planning Area (Dickey, personal communication, 2010).

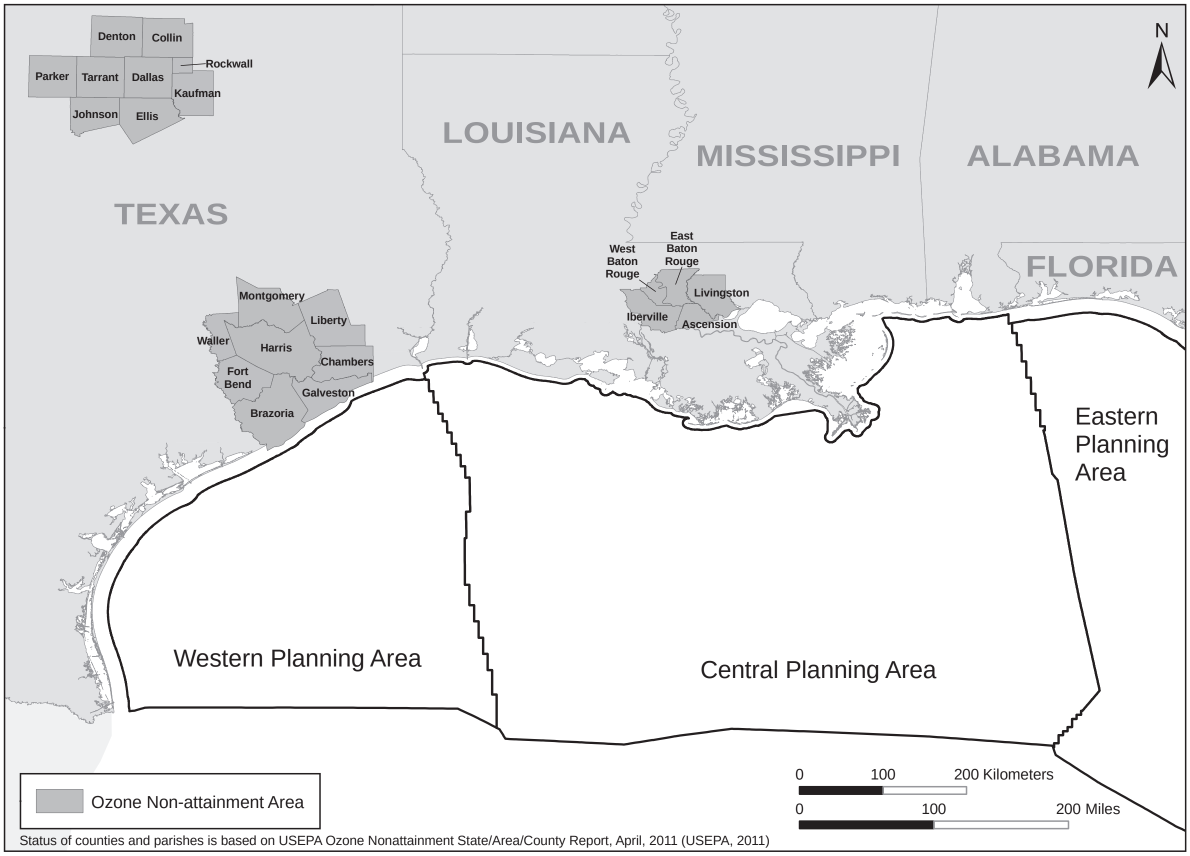

Figure 4-1. Status of Ozone Attainment in Coastal Counties and Parishes of the Central and Western Planning Areas (USEPA, 2011).

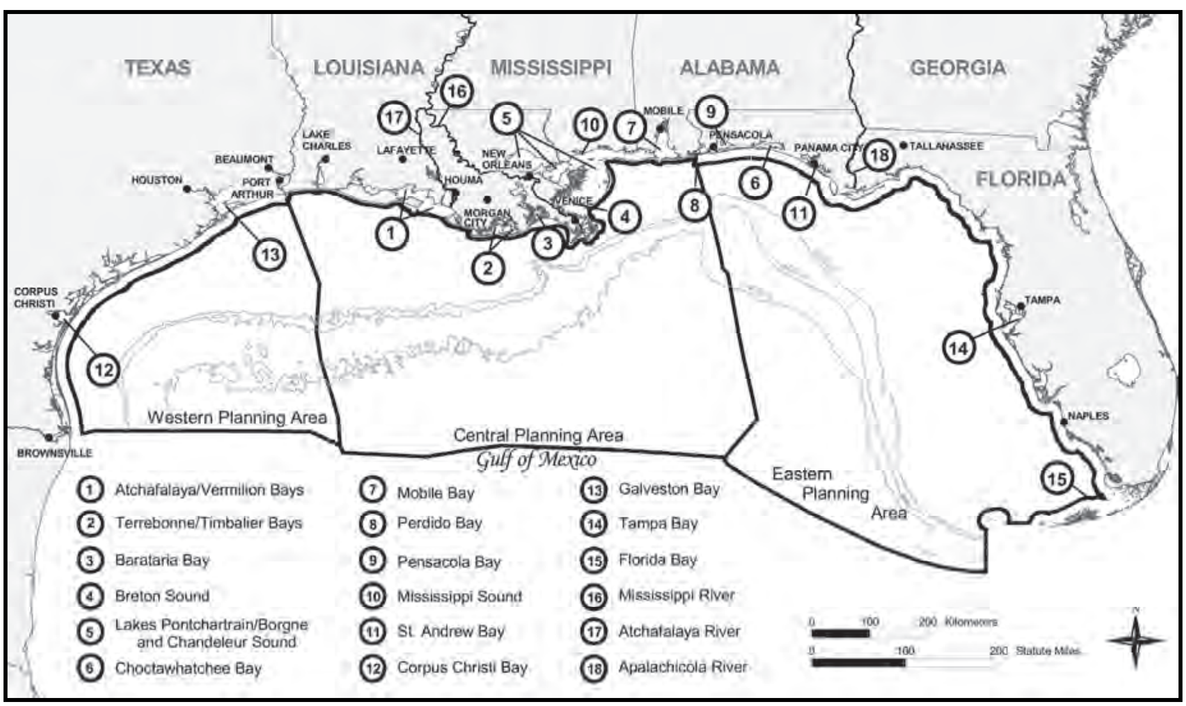

Figure 4-2. Coastal and Marine Waters of the Gulf of Mexico with Selected Rivers and Water Depths.

Figure 4-3. Seagrass Locations of the Northern Gulf of Mexico.

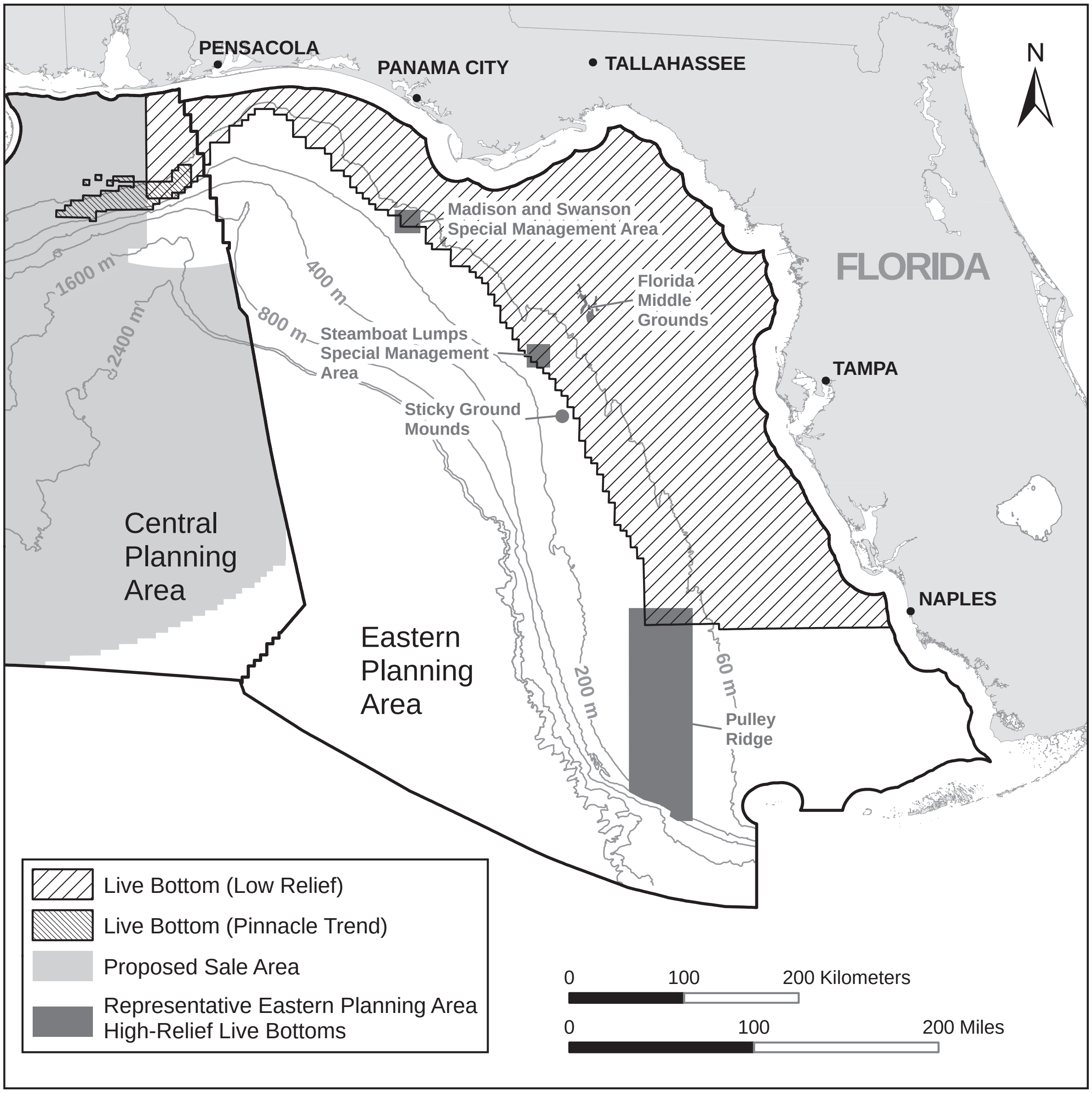

Figure 4-4. Live Bottoms (Low Relief and Pinnacle Trend) in the Central and Eastern Planning Areas.

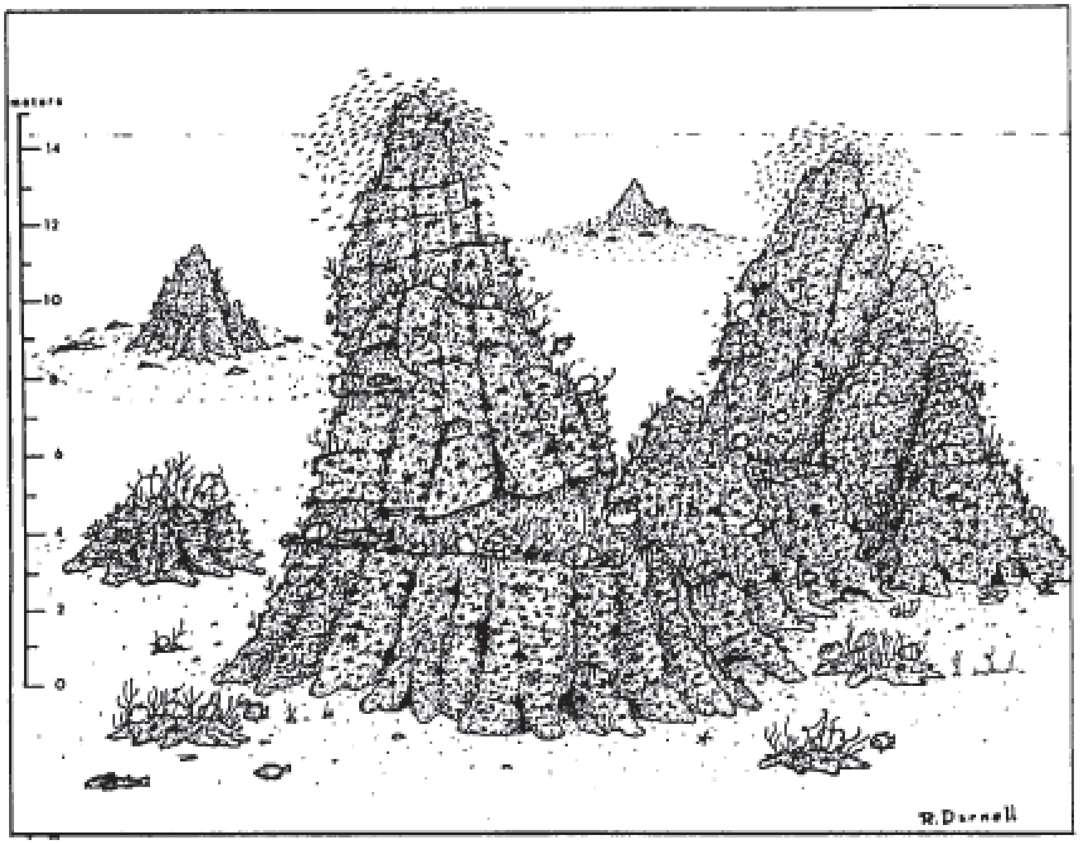

Figure 4-5. Perspective Sketch of the Submerged Landscape of a Pinnacle Province as Visualized from Sidescan Sonar and Remotely Operated Vehicle Information (Brooks and Giammona, 1990).

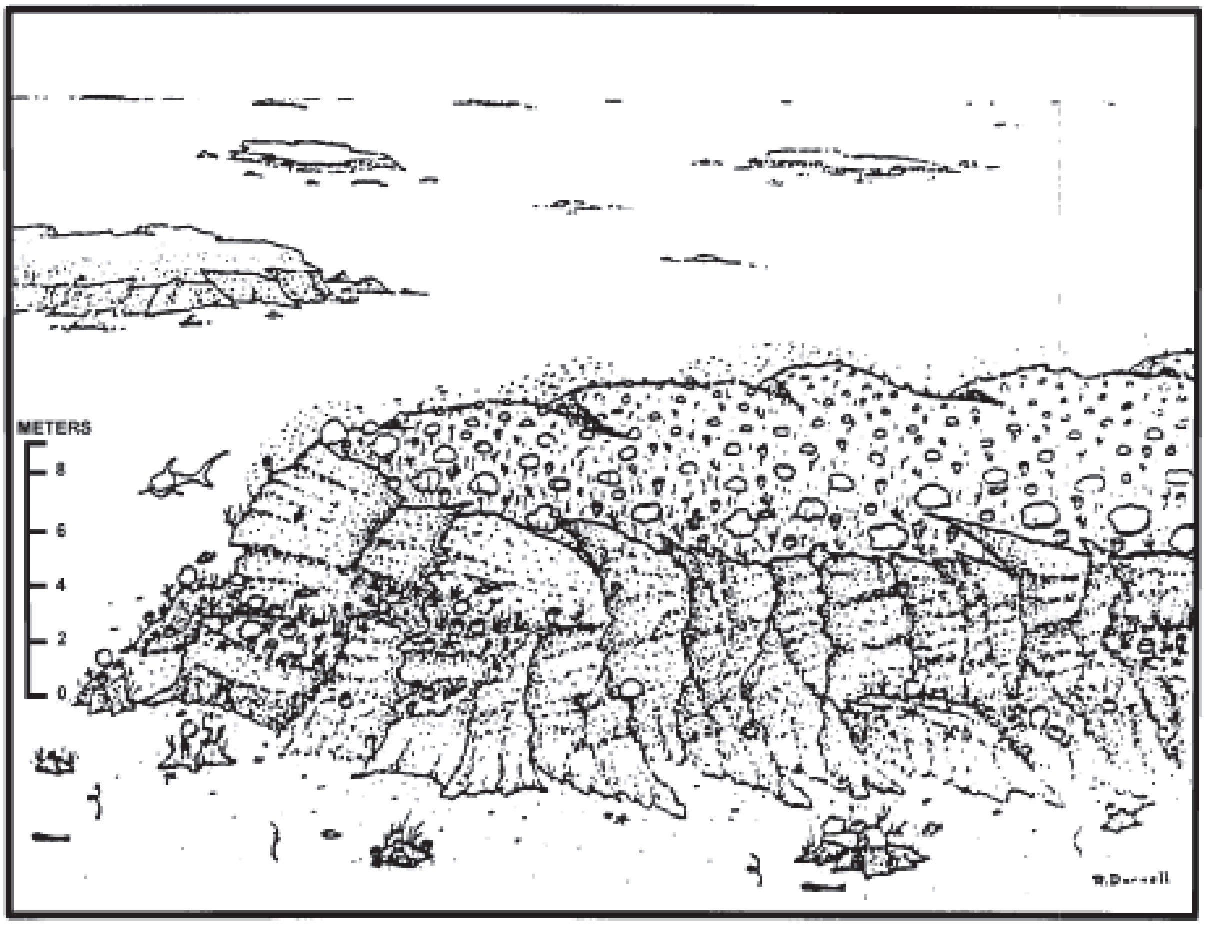

Figure 4-6. Sketch of a Submerged Ridge (Brooks and Giammona, 1990).

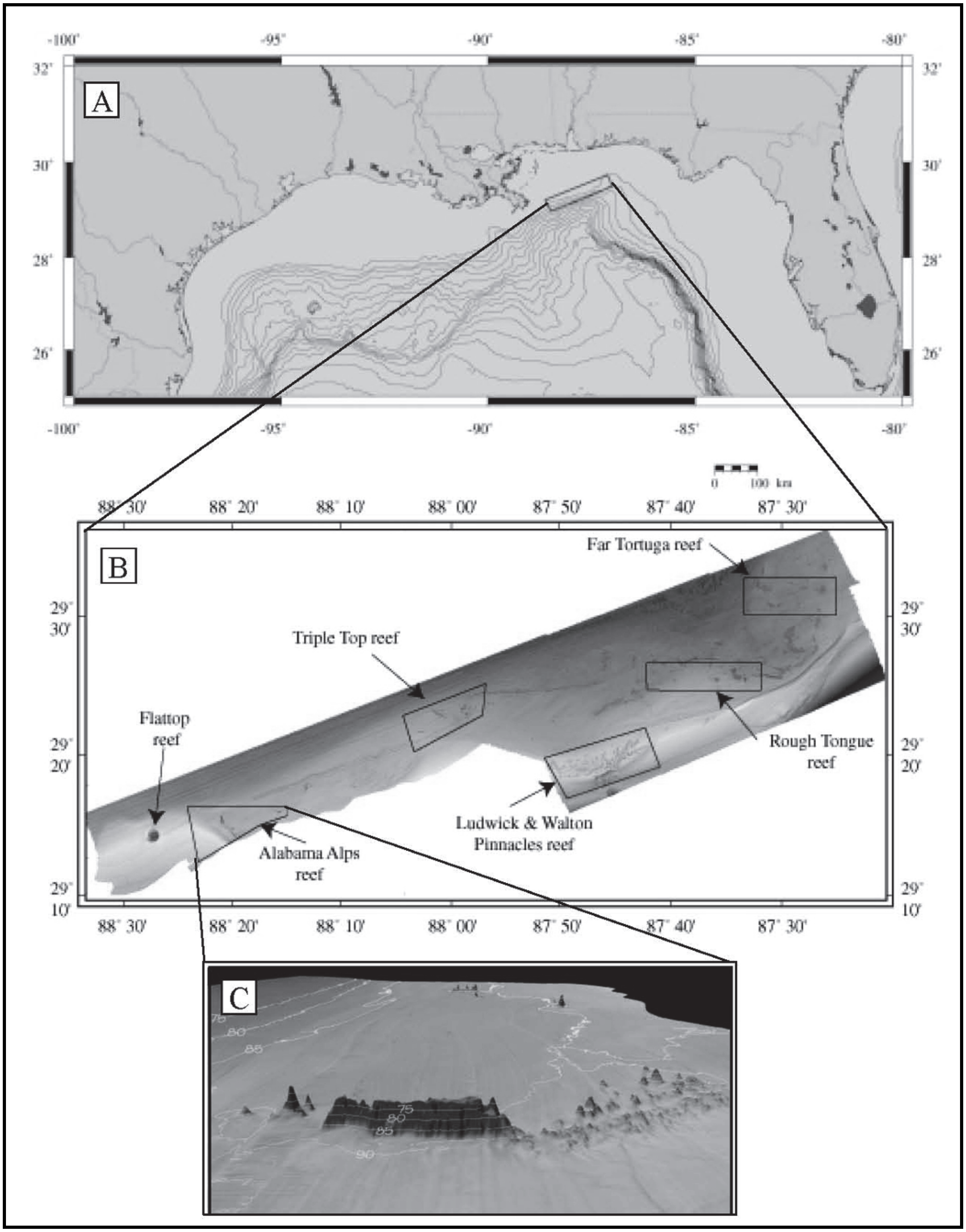

Figure 4-7. Location of the 36 Fathom Ridge within the Alabama Alps Formation (A & B) (Gardner et al., 2002) and Oblique View of the 36 Fathom Ridge within the Alabama Alps (C) (Weaver et al., 2002).

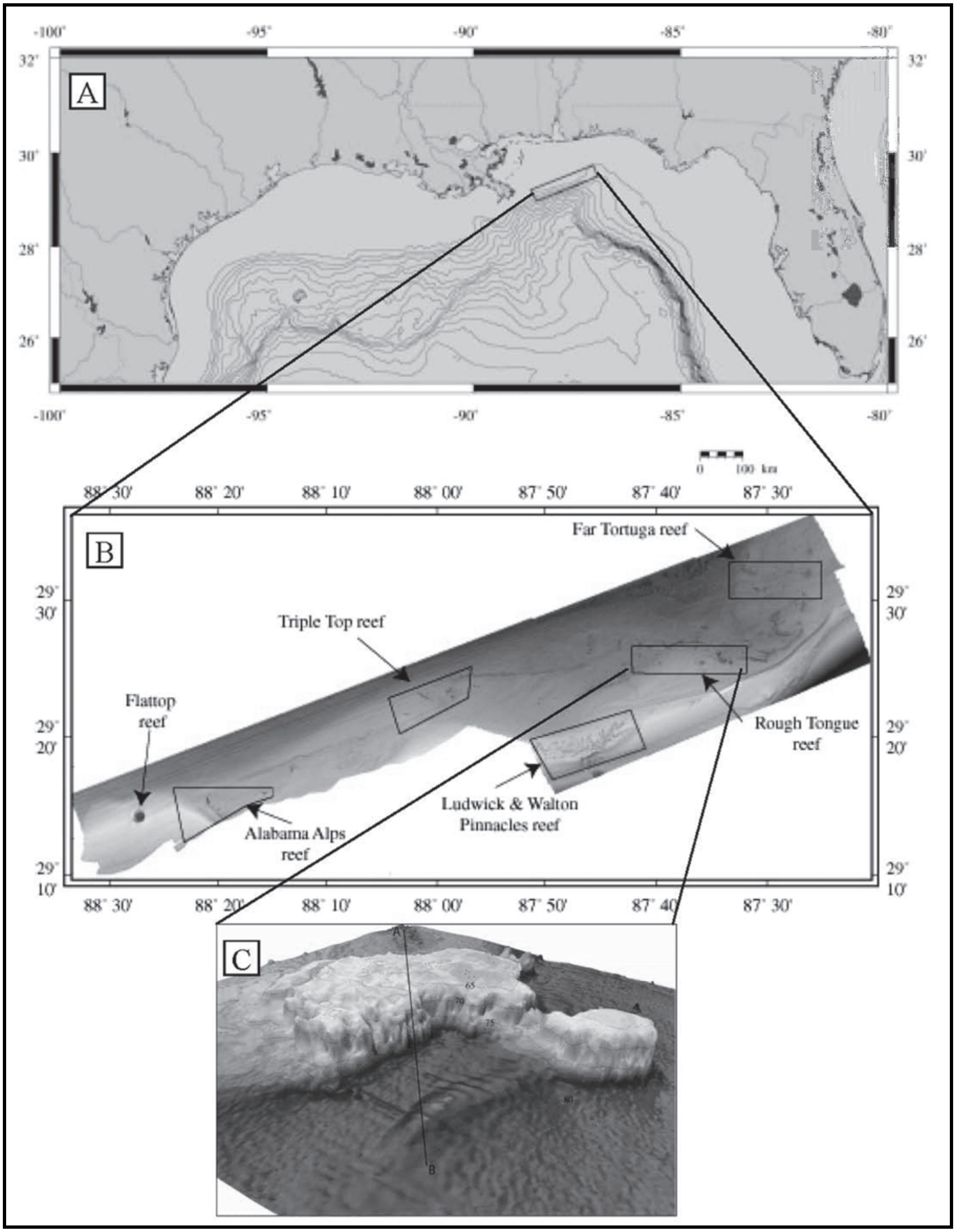

Figure 4-8. Location of Roughtongue Reef (A & B) (Gardner et al., 2002) and Oblique View of Roughtongue Reef (C) (Weaver et al., 2002).

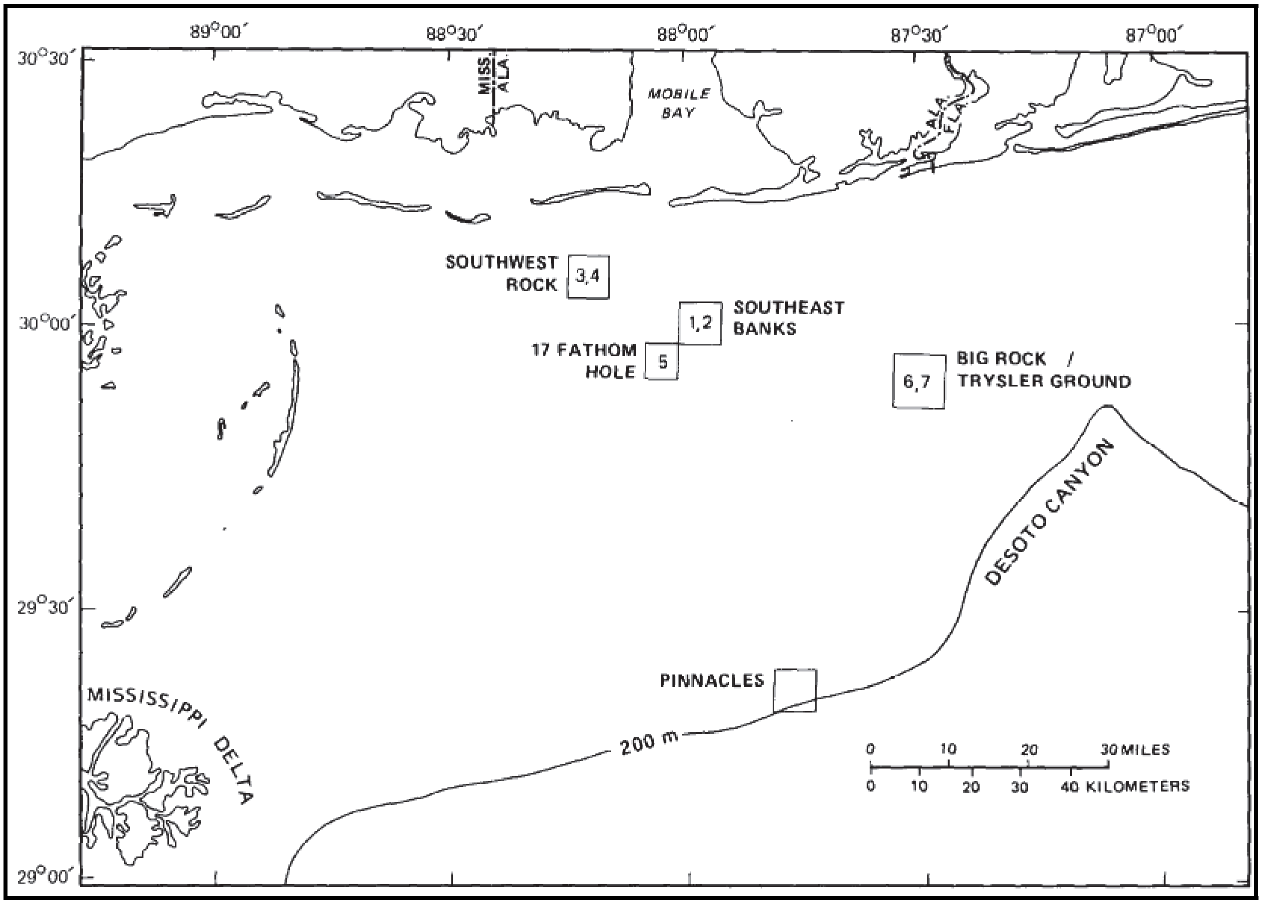

Figure 4-9. Location of Some Mapped Low-Relief, Hard-Bottom Areas and Pinnacles on the Alabama-Florida Continental Shelf (Schroeder et al., 1988).

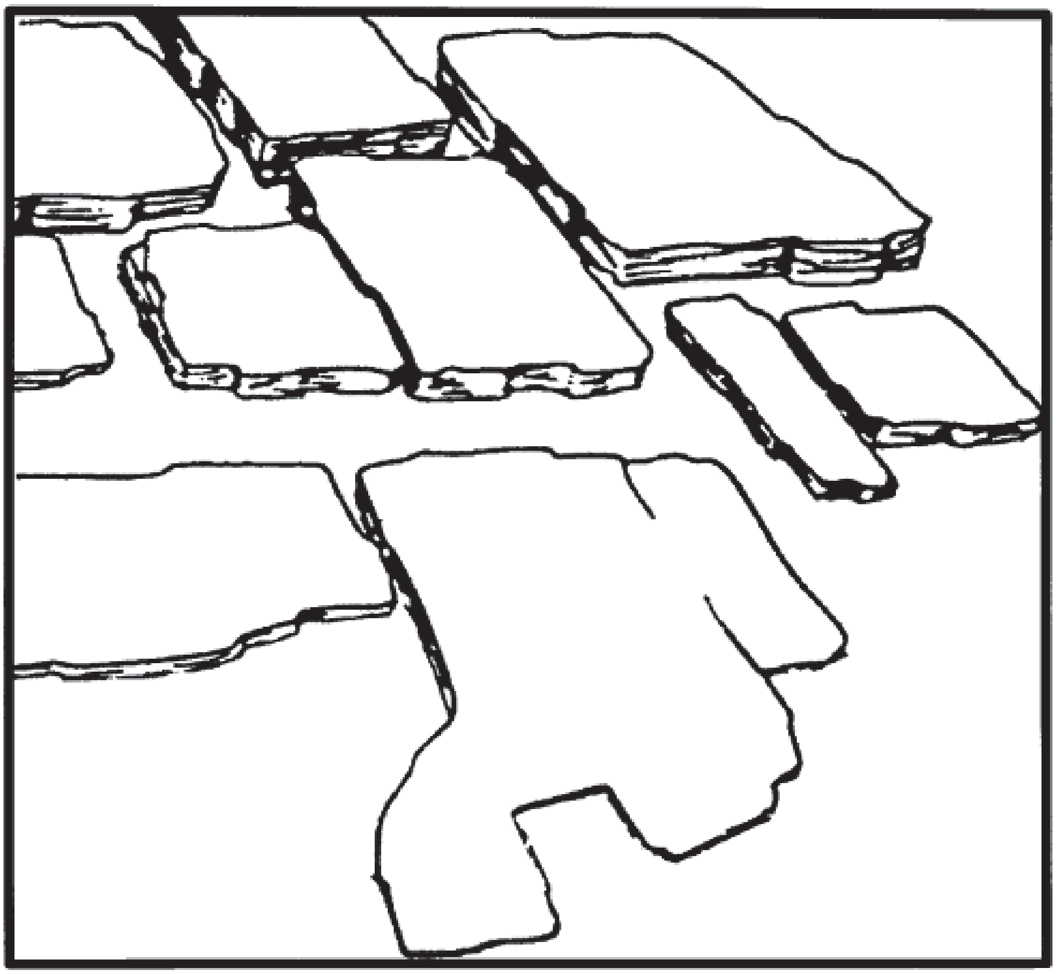

Figure 4-10. Block-Like, Hard-Bottom Substrate North of the Head of De Soto Canyon (Shipp and Hopkins, 1978).

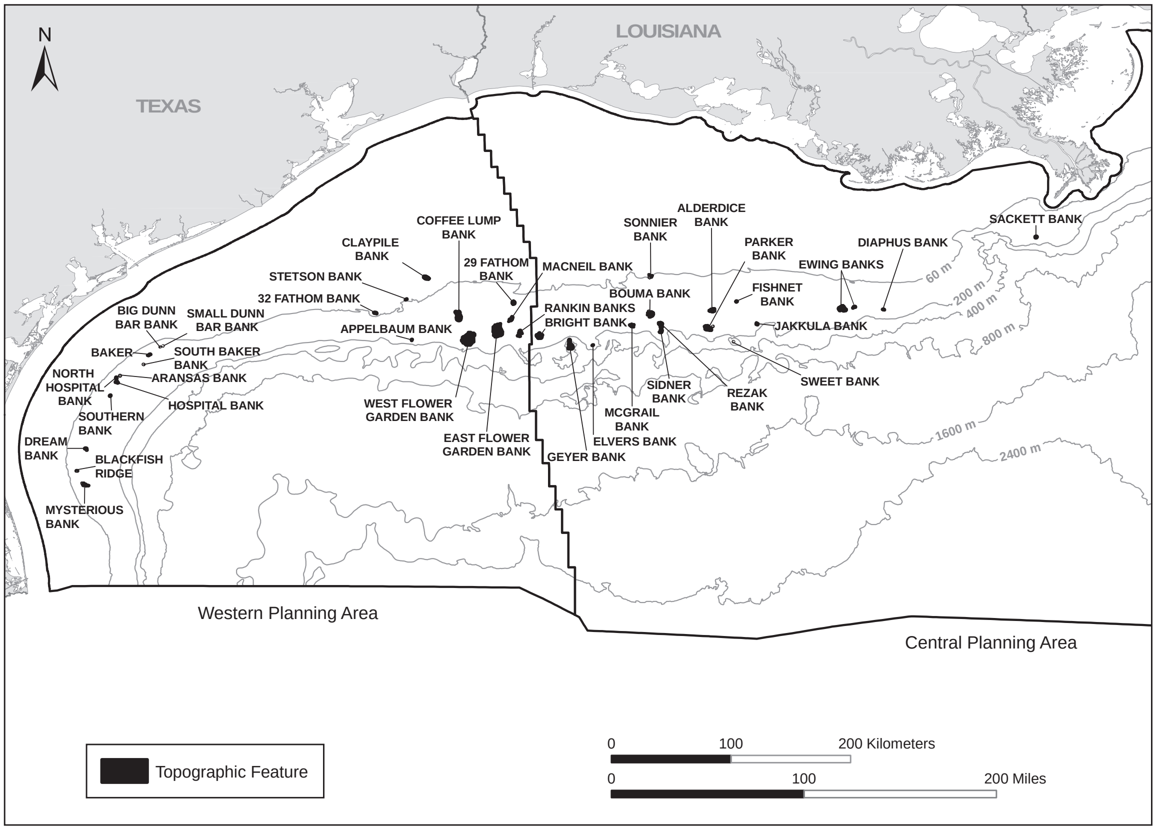

Figure 4-11. Location of Topographic Features in the Gulf of Mexico.

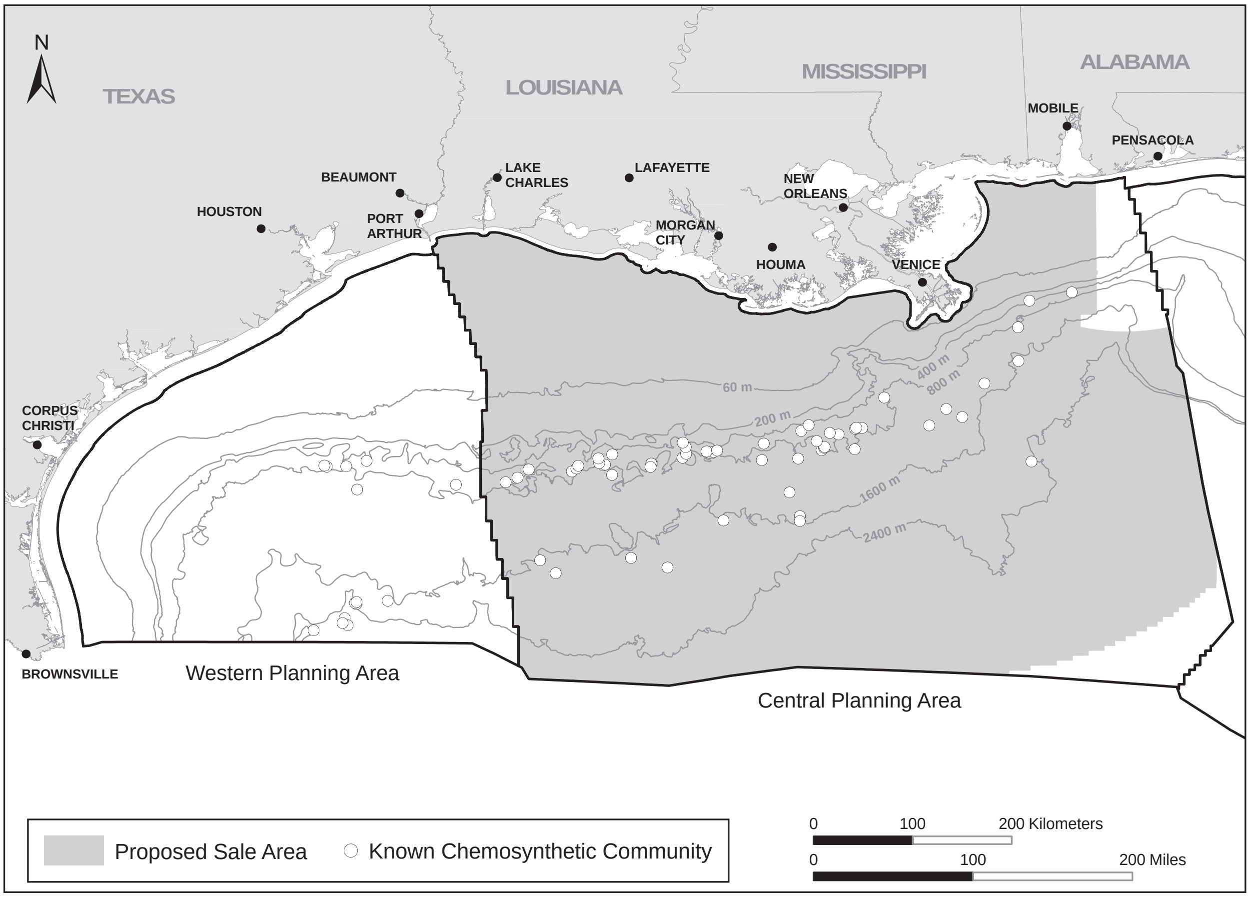

Figure 4-12. Location of Known Chemosynthetic Communities in the Gulf of Mexico.

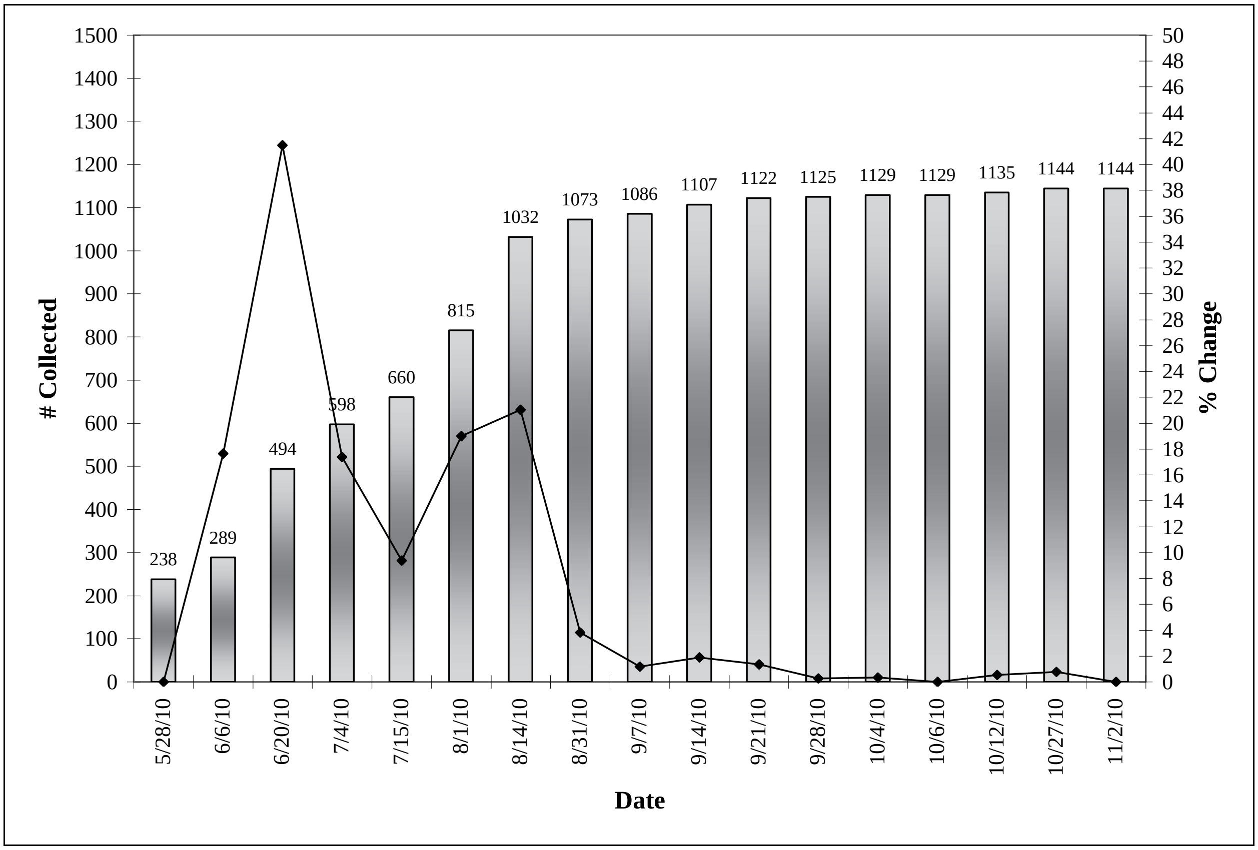

Figure 4-13. Summary of Sea Turtles Collected by Date Obtained from the Consolidated Numbers of Collected Fish and Wildlife That Have Been Reported to the Unified Area Command from the U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Incident Area Commands, Rehabilitation Centers, and Other Authorized Sources Operating within the *Deepwater Horizon*/BP Incident Impact Area through November 2, 2010. (Data on the Y-axis reflects the cumulative number of individual sea turtles collected by date [alive and dead] and data on the Z-axis reflects proportional change from one reporting date to the next. For the latest available information on oiled or affected sea turtles documented in the area, event response, and daily maps of the current location of spilled oil, see RestoreTheGulf.gov, 2011).

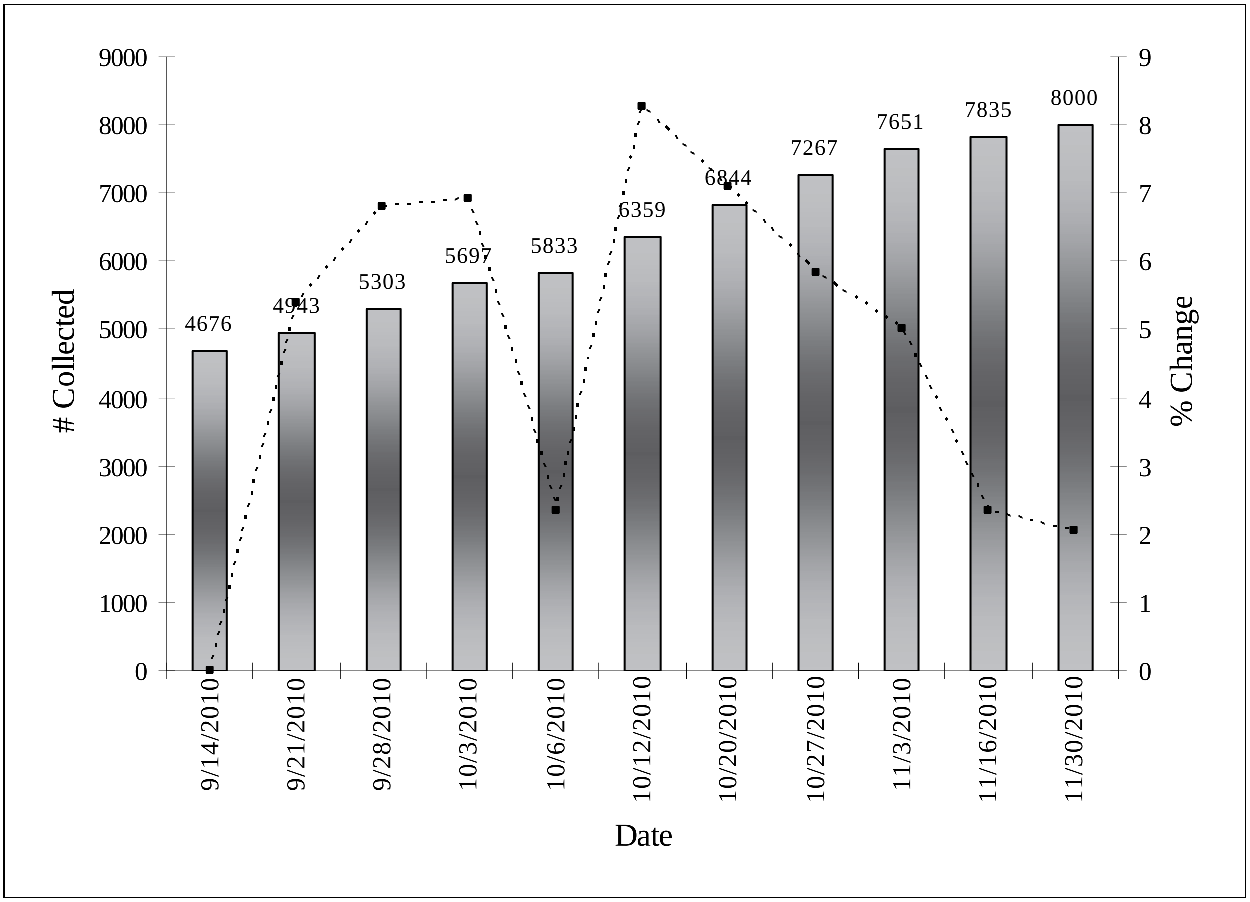

Figure 4-14. Summary of Avian Species Collected by Date Obtained from the U.S. Fish and Wildlife Service (FWS) as Part of the NRDA Process through November 30, 2010. (Data on the Y-axis reflects the cumulative number of individual birds collected, identified, and summarized by date; data on the Z-axis reflects proportional change from one reporting date to the next. The data used in this table are verified as per the FWS QA/QC processes. Disclaimer: All data should be considered provisional, incomplete, and subject to change. For more information, see USDOI, FWS, 2010).

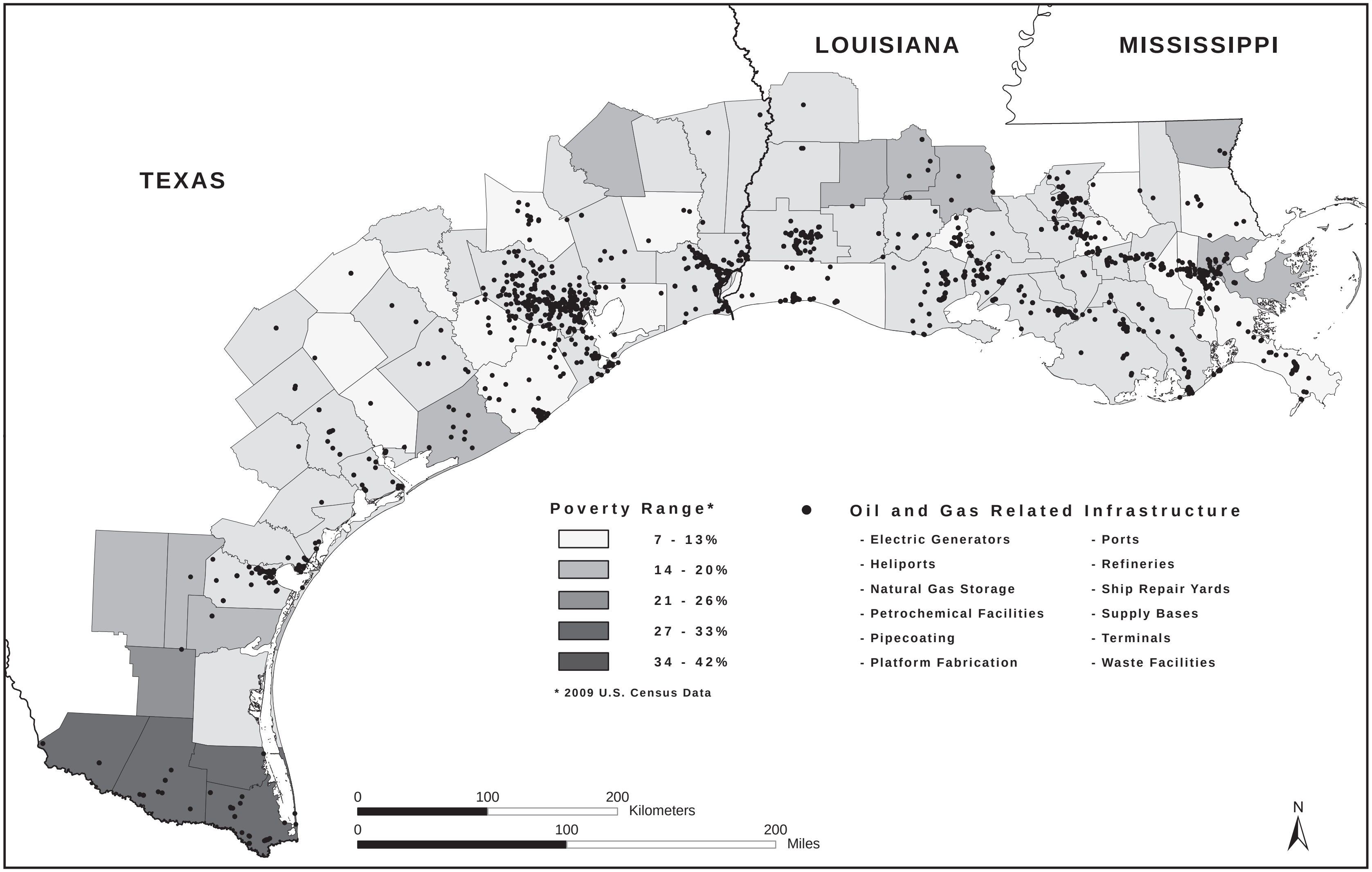

Figure 4-15. Locations of Oil- and Gas-Related Infrastructure and the Distribution of Low-Income Residents across Counties and Parishes in Texas and Louisiana based on U.S. Census Data from 2009 (USDOC, Census Bureau, 2010; Dismukes, in preparation).

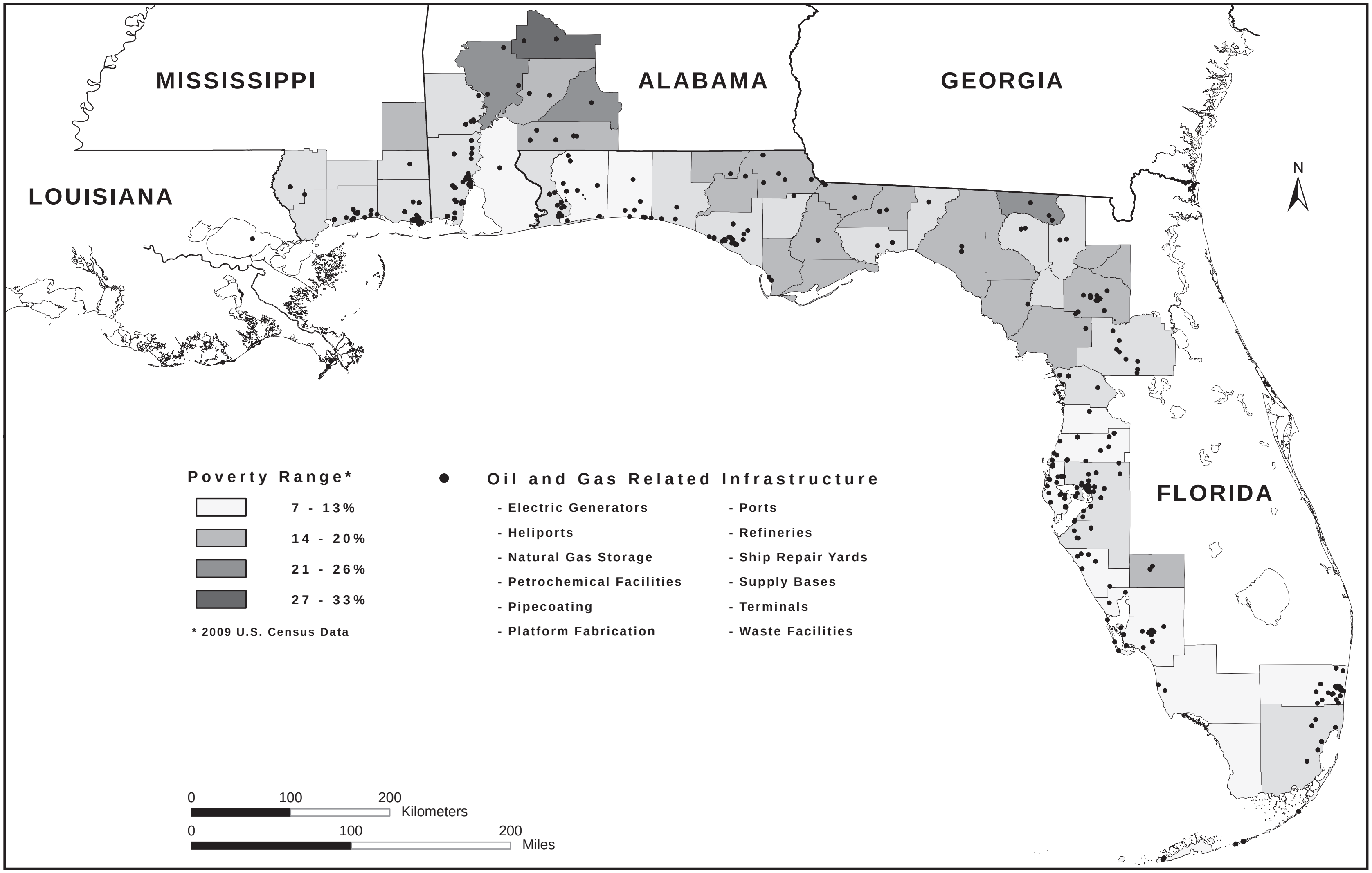

Figure 4-16. Locations of Oil- and Gas-Related Infrastructure and the Distribution of Low-Income Residents across Counties in Mississippi, Alabama, and Florida based on U.S. Census Data from 2009 (USDOC, Census Bureau, 2010; Dismukes, in preparation).

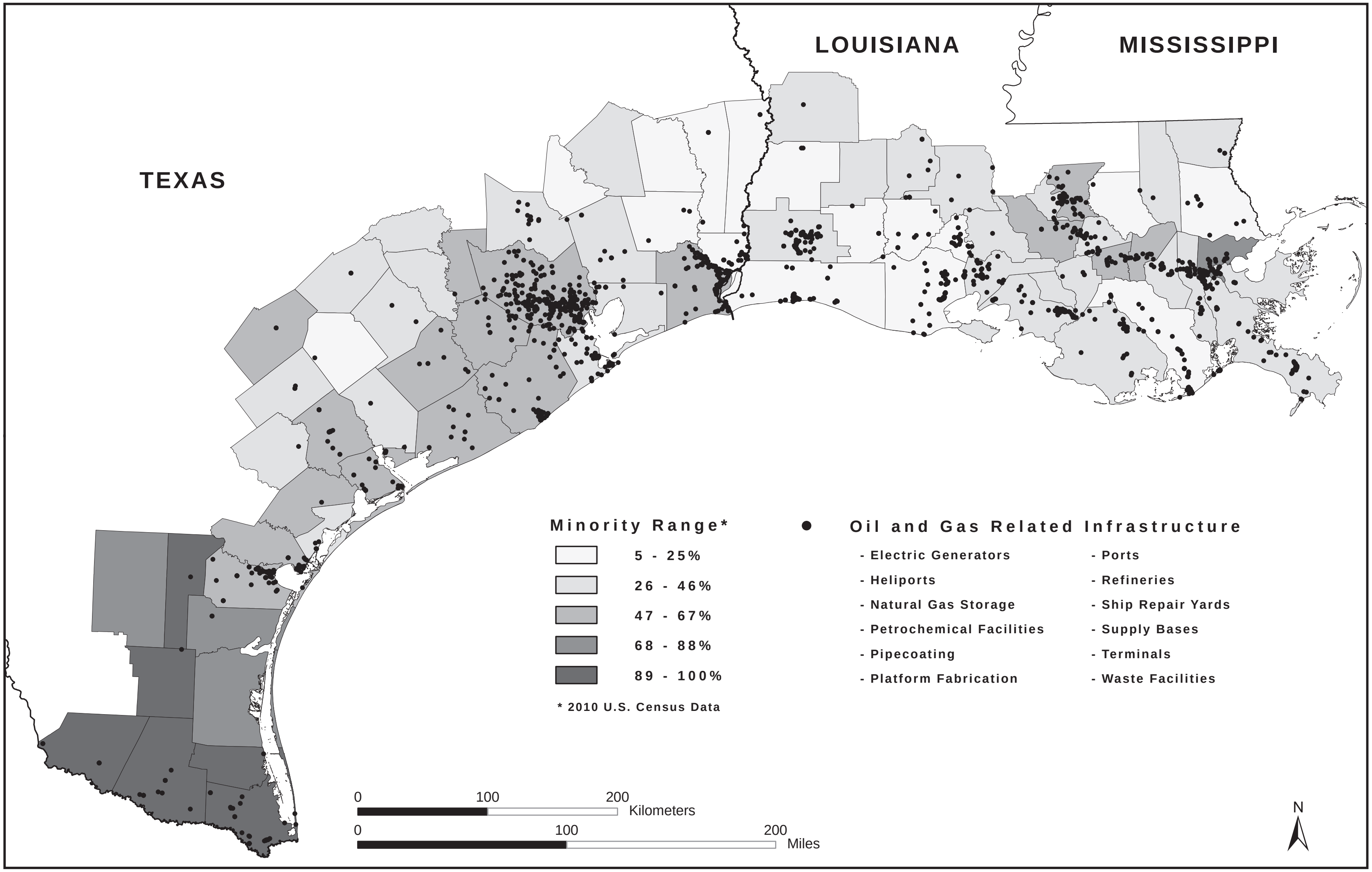

Figure 4-17. Locations of Oil- and Gas-Related Infrastructure and the Distribution of Minority Residents across Counties and Parishes in Texas and Louisiana based on U.S. Census Data from 2009 (USDOC, Census Bureau, 2010; Dismukes, in preparation).

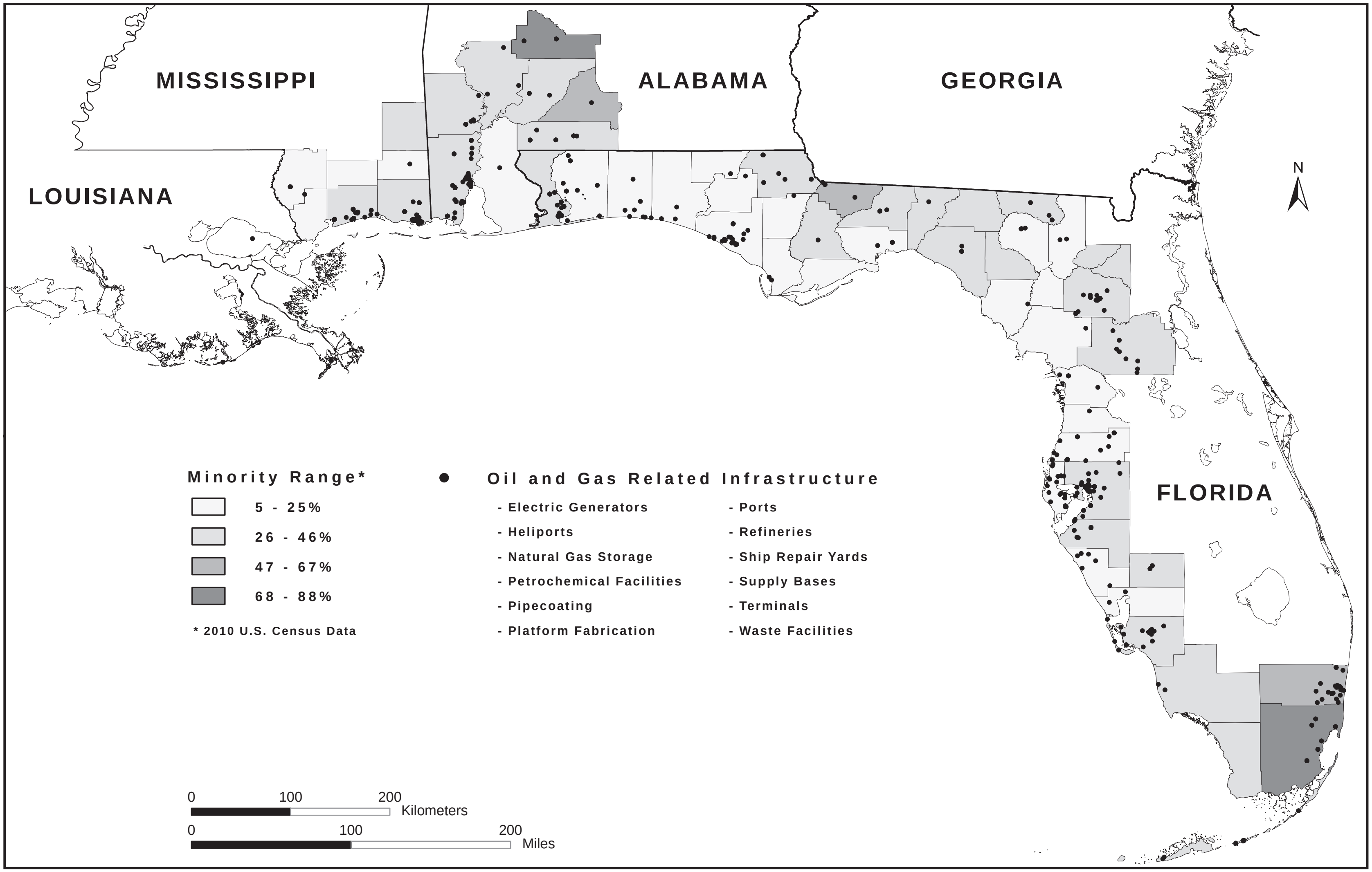

Figure 4-18. Locations of Oil- and Gas-Related Infrastructure and the Distribution of Minority Residents across Counties in Mississippi, Alabama, and Florida based on U.S. Census Data from 2009 (USDOC, Census Bureau, 2010; Dismukes, in preparation).

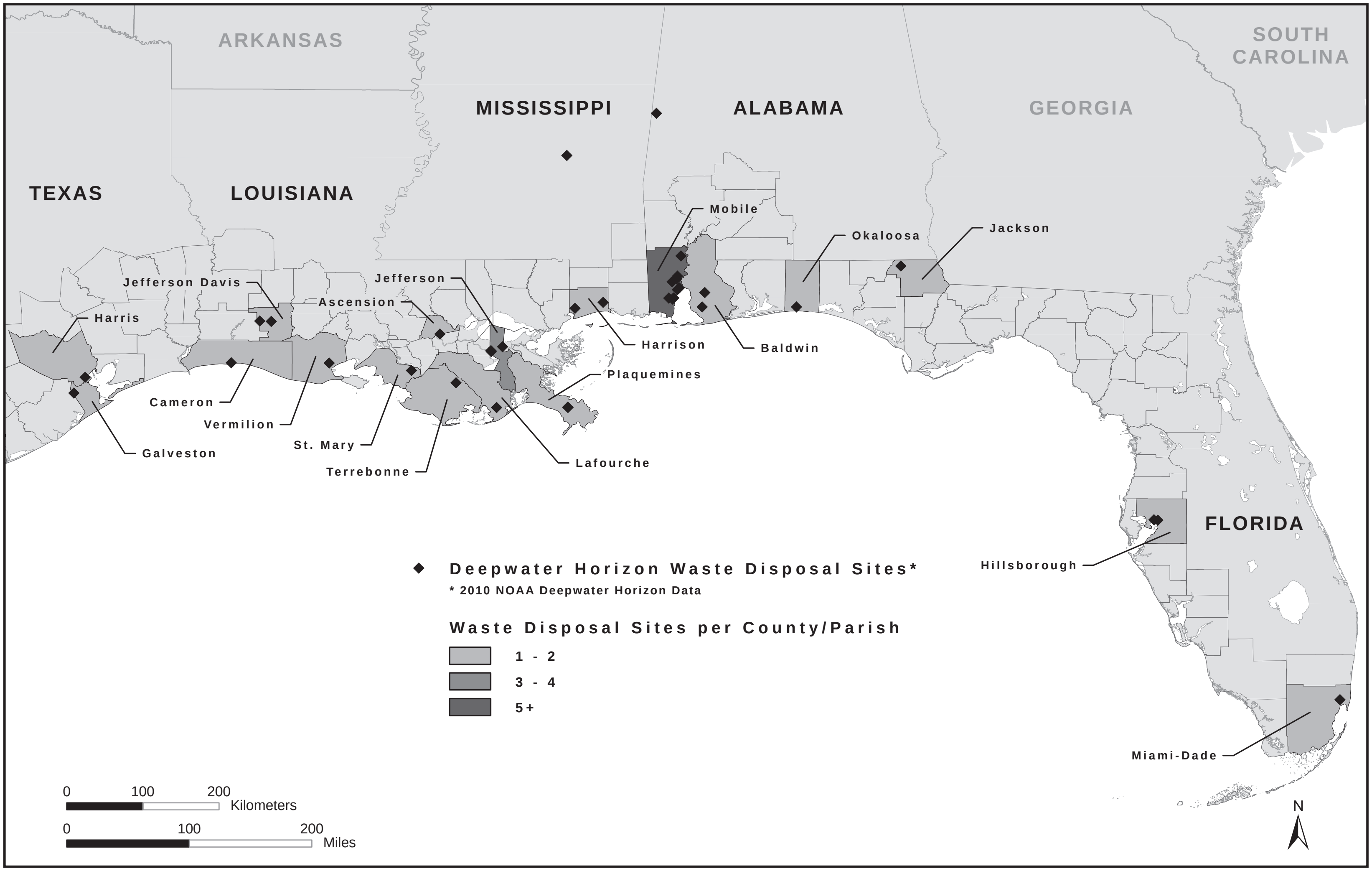

Figure 4-19. Location of All *Deepwater Horizon* Waste Disposal Sites (USDOC, NOAA, 2011; USEPA and British Petroleum, 2010; British Petroleum, 2011a and 2011b).

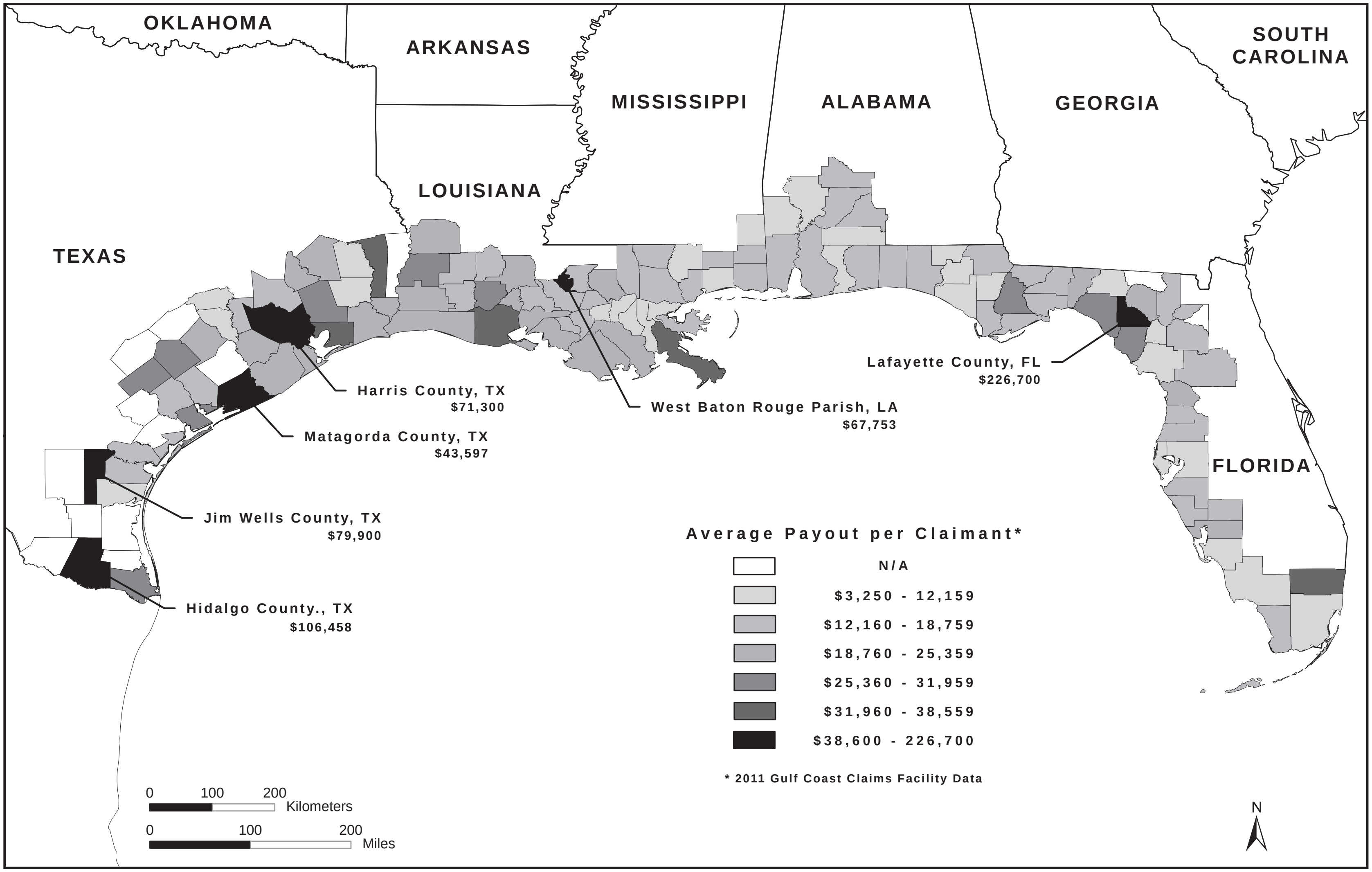

Figure 4-20. Distribution of the Gulf Coast Claims Facility's Claimants and the Average Amount Paid to Each Claimant across Gulf of Mexico Counties and Parishes (Gulf Coast Claims Facility, 2011).

Table 1-1

Emergency 30 CFR 250 Subpart D Interim Final Rule Provisions

Regulation	Summary	Existing Requirement	New Requirement	Cost
30 CFR §250.415(f)	Evaluate best practices in API RP 65-Part2	No evaluation required	Requires the operator to evaluate the best practices according to API RP 65-Part 2 and submit a written description for the evaluation.	No meaningful cost
			Written description must include the mechanical barriers and cementing practices the operator will use for each casing string.	
			API RP 65 Part 2 addresses cementing practices and factors affecting cementing success.	
30 CFR §250.416(d)	Submittal of schematics of all control systems for BOP stack	Schematic of BOP system showing inside diameter of BOP stack, number and type of preventers, location of choke and kill lines	Schematics of all control systems, including primary controls, secondary controls, and pods for the BOP system must be submitted.	No meaningful cost
			Location of the controls must be included	
30 CFR §250.416(e)	Independent third party verification to ensure blind-shear rams are capable of cutting the drill pipe used	Information that the blind-shear ram is capable of shearing the pipe	Verification that the blind-shear rams installed in the BOP stack are capable of shearing the drill pipe in the hole under maximum anticipated surface pressure.	Independent third-party certification will require a small cost per well
		No independent third-party certification required	Independent third party must be a technical classification society or an API licensed manufacturing, inspection, certification firm, or licensed professional engineering firm.	Will add moderate costs
			Independent third-party must not be the OEM.	
30 CFR §250.418(i)	Submit qualifications of independent third parties with APD	No independent third-party certification required	Description of qualifications in accordance with §250.416 (e)	No meaningful cost

Table 1-1. Emergency 30 CFR 250 Subpart D Interim Final Rule Provisions (continued).

Regulation	Summary	Existing Requirement	New Requirement	Cost
30 CFR §250.420(a)(6)	Professional Engineer verification of well casing and cementing program	No PE verification required	PE will verify there are two independent barriers	Small cost per well if performed by an independent third party
			Verify the casing cementing design is appropriate for the purpose it was intended under expected wellbore conditions	No cost if PE certification is done in house
				Assumed that some majors would verify in-house; smaller operators will use third party
30 CFR §250.420(b)(3)	Dual mechanical barriers	No requirement	Operator must install dual mechanical barriers in addition to cement in the final casing string and document to BOEMRE. Dual float valves, or one float valve and a mechanical plug.	Estimated that 80% of wells already use dual mechanical barriers
				Installation of dual mechanical barriers is estimated to take 21 hours
				Will add significant costs to regulation
30 CFR §250.423(b)(2)	Pressure test on the casing seal assembly	Perform a pressure test on all casing strings (except drive/structural) according to 250.423 (a)	Additional pressure test for the intermediate and production casing strings on the casing seal assembly to ensure proper installation of the casing in the subsea wellhead.	Pressure tests are already required, no extra equipment time
		No requirement to ensure proper installation of the casing in the subsea wellhead		Each pressure test only takes a few minutes
				No meaningful cost
30 CFR §250.423(c)	Negative pressure test	No negative pressure test required	Perform a negative pressure test to ensure proper installation of intermediate and production casing strings	Negative pressure test will take 90 minutes for each required string of casing
				Will result in significant costs for the regulation
30 CFR §250.442(e)	Maintain ROV and a trained crew	ROV's used for visual inspection every 3 days; 250.446(b)	Required to maintain an ROV and trained crew on each floating rig on a continuous basis.	All rigs are assumed to have an ROV on board. This regulation will not add additional costs.

Table 1-1. Emergency 30 CFR 250 Subpart D Interim Final Rule Provisions (continued).

Regulation	Summary	Existing Requirement	New Requirement	Cost
			ROV must be capable of shutting in the well during emergency situations	Regulation does not require a timed test, therefore current ROV's will be capable of performing all required functions.
30 CFR §250.442(f)	Provide an autoshear and deadman system for dynamically positioned rigs	No autoshear/deadman system requirement	All dynamically positioned rigs must have an autoshear and deadman system	Industry standard for dynamically positioned rigs to have autoshear/deadman systems No meaningful cost
30 CFR §250.442(g)	Barriers on BOP control panels to prevent accidental disconnect functions	No two-handed requirement	Incorporate enable buttons on control panels to ensure 2-handed operations for all critical functions.	No meaningful cost
30 CFR §250.442(h)	Label subsea BOP control panel	No labeling requirement	Clearly label all control panels, such as hydraulic control panels and ROV interface on the BOP	No meaningful cost
30 CFR §250.442(i)	Develop management system for BOP	No management requirement	Develop and use a management system for operating the BOP system	No meaningful cost
			Written procedures for operating the BOP stack and LMRP	
			Minimum knowledge requirements for personnel authorized to operate and maintain critical BOP components	
30 CFR §250.442(j)	Training for BOP equipment	No training requirement	Train BOP personnel in deepwater well control theory and practice in accordance with 30 CFR 250, Subpart O	No meaningful cost
30 CFR §250.446(a)	Document maintenance and inspections to BOP system	No documentation requirement	BOP maintenance and inspections must meet or exceed provisions of Sections 17.10 and 18.10	No meaningful cost
30 CFR §250.449(j)	Subsea function test for ROV intervention	No initial test on the seafloor	All ROV intervention functions must be tested during the stump test and one set of rams during the initial test on the seafloor	Initial test on the seafloor is not industry standard

Table 1-1. Emergency 30 CFR 250 Subpart D Interim Final Rule Provisions (continued).

Regulation	Summary	Existing Requirement	New Requirement	Cost
	on a subsea BOP stack	Stump test for subsea BOP stack	ROV hot stabs must be function tested and capable of actuating at least 1 set of pipe rams, 1 set of blind-shear rams and unlatching the LMRP	ROV seafloor test is estimated to take about 24 hours Will add significant costs
			Operator must examine all surface and subsea well-control equipment to ensure that it is properly maintained and capable of shutting in the well during emergency operations	
30 CFR §250.449(k)	Autoshear/ deadman function test	No required function test	The autoshear and deadman systems must be function tested during the stump test and during the initial test on the seafloor.	No meaningful cost
30 CFR §250.451(i)	Emergency activation of blind or casing shear rams	No required action	If the blind-shear or casing shear rams are activated in a well control situation, the BOP must be retrieved and fully inspected and tested	Emergency situation only, will incur significant loss of rig time
30 CFR §250.456(j)	District Manager approval for displacing kill-weight drilling fluid	No approval requirement	Approval required from District Manager before displacing kill-weight drilling fluid from the wellbore	No meaningful cost
			Submit reasons for displacing and provide detailed procedures of displacement process.	
			Follow procedures in 250.456	
30 CFR §250.516(d)(8)	Subsea function test for ROV intervention on a subsea BOP stack	Stump test BOP stack before installation	All ROV intervention functions must be tested during the stump test and 1 set of rams during the initial test on the seafloor	Will add costs for well completions operations
			ROV hot stabs must be function tested and capable of actuating at least 1 set of pipe rams, 1 set of blind-shear rams and unlatching the LMRP	
			Operator must examine all surface and subsea well-control equipment to ensure that it is properly maintained and capable of shutting in the well during emergency operations	

Table 1-1. Emergency 30 CFR 250 Subpart D Interim Final Rule Provisions (continued).

Regulation	Summary	Existing Requirement	New Requirement	Cost
30 CFR §250.616(h) (1)	Subsea function test for ROV intervention on a subsea BOP stack	Stump test BOP stack before installation	All ROV intervention functions must be tested during the stump test and 1 set of rams during the initial test on the seafloor	Will add costs for well workover operations
			ROV hot stabs must be function tested and capable of actuating at least 1 set of pipe rams, 1 set of blind-shear rams and unlatching the LMRP	
			Operator must examine all surface and subsea well-control equipment to ensure that it is properly maintained and capable of shutting in the well during emergency operations	

Source: *Federal Register*, 2010.

Table 2-1

Presidential and Secretarial Inquiries Resulting from the *Deepwater Horizon* Event and Spill

Initiator and Date	Purpose	Expected Outputs
April 30, 2010 President Obama	Reported if additional precautions and technologies should be required to improve the safety of oil and gas operations on the OCS.	The so-called "30-day Report" or "Safety Measures Report" was delivered to the Secretary on May 27, 2010 (USDOI, 2010a).
April 30, 2010 Secretary Salazar	Created OCS Safety Oversight Board (Board) to provide recommendations for improving and strengthening DOI's overall management, regulation, and oversight of OCS operations, including undertaking further audits or reviews, and reviewing existing authorities and procedures.	The Board delivered its report to the Secretary on September 1. It was made public with an implementation plan on September 8, 2010 (USDOI, 2010b).
May 11, 2010 Secretary Salazar	Impaneled a review by the National Academy of Engineering (NAE) of the root causes of the *Deepwater Horizon* event and provide recommendations	The NAE panel forecasts delivery of their final report that presents the Committee's final analysis, including findings and/or recommendations, by June 1, 2011 (pre-publication version); a final published version will follow by December 30, 2011 (NAE and NRC, 2011).
May 21, 2010 President Obama	Created the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling to develop findings and recommendations within 6 months.	The Commission delivered the Final Report to the President on January 11, 2011 (Oil Spill Commission, 2011).
May 25, 2010 Secretary Salazar	Requested that the DOI's Office of the Inspector General investigate any deficiencies in BOEMRE policies and practices that may have contributed to the *Deepwater Horizon* event.	The DOI's Office of the Inspector General released its report on December 7, 2010 (USDOI, Office of the Inspector General, 2010).

Table 3-1

Projected Oil and Gas in the Gulf of Mexico OCS

	Proposed Action	OCS Program (2007-2046)
Western Planning Area		
Reserve/Resource Production		
Oil (BBO)	0.222-0.423	6.629-8.060
Gas (Tcf)	1.495-2.647	52.211-59.961
Central Planning Area		
Reserve/Resource Production		
Oil (BBO)	0.801-1.624	21.933-24.510
Gas (Tcf)	3.332-6.560	90.155-102.761

BBO = billion barrels of oil

Tcf = trillion cubic feet

Table 3-2

Offshore Scenario Information Related to a Proposed Action in the Central Planning Area

	Offshore Subareas[1]							
	0-60 m	60-200 m	200-400 m	400-800 m	800-1,600 m	1,600-2,400 m	>2,400 m	Total CPA[2]
Wells Drilled								
Exploration and Delineation Wells	17-23	9-14	6-14	9-17	11-24	7-16	6-13	65-121
Development and Production Wells	62-85	23-33	76-132	65-102	58-112	37-73	20-39	338-576
Producing Oil Wells	14-19	6-9	38-66	32-52	30-58	19-38	10-21	149-263
Producing Gas Wells	40-55	14-20	28-48	22-36	20-39	13-26	7-13	144-237
Production Structures								
Installed	20-25	2-3	2-3	2-3	1-4	2-3	3	32-44
Removed Using Explosives	14-17	2	2	0-1	0	0	0	23-32
Total Removed	18-23	2-3	2-3	2-3	1-4	2-3	3	30-42
Length of Installed Pipelines (km)[3]	50-850	NA	NA	NA	NA	NA	NA	130-2,075
Service-Vessel Trips (1,000's round trips)	22-27	3-5	5-9	5-8	19-69	34-52	49-50	137-220
Helicopter Operations (1,000 operations)	714-1,185	71-169	36-169	36-169	36-226	36-169	75-154	1,004-2,241

[1] See Figure 3-1.

[2] Subareas totals may not add up to the planning area total because of rounding.

[3] Projected length of pipelines does not include length in State waters.

NA = not available.

Table 3-3

Deepwater Rig Counts, Day Rates, and Annual Drill Rates in the Gulf of Mexico*

Rig Type	Number of Rigs	Loaded Day Rate
Drillship	11	$1,000,000
Deep Semisubmersible	21	$923,953
Low Semisubmersible	4	$715,792
MODU Total or Weighted Average	36	$924,060
Platform	10	$400,000

* Current to August 2010.

Table 3-4

Oil Spilled from Pipelines on the Federal OCS, 2002-2009

Regulator	Area	Total Oil Spilled (bbl)	Oil Spilled due to Hurricanes (bbl)	Proportion of Total due to Hurricanes (%)
BOEMRE	Federal OCS	5,522	5,179	94
DOT	Federal OCS	5,667	3,272	58
DOT	State Waters	9,903	9,622	97

Source: USDOI, BOEMRE and DOT data.

Table 3-5

Mean Number and Sizes of Spills Estimated to Occur
in OCS Offshore Waters from an Accident Related
to Activities Supporting the Proposed Action Over a 40-Year Time Period

Spill Size Group	Spill Rate (spills/BBO) [1]	Number of Spills Estimated for a WPA Proposed Action [2]	Number of Spills Estimated for a CPA Proposed Action [2]	Estimated Spill Size [1]
0-1.0 bbl	3,357.31	745-1,420	2,690 -5,452	0.07[3]
1.1-9.9 bbl	74.7	17-32	60-121	3[4]
10.0-49.9 bbl	16.18	4-7	13-27	20[4]
50.0-499.9 bbl	6.37	1-3	5-11	90[4]
500.0-999.9 bbl	0.52	<1	<1-1	640[4]
≥1,000 bbl	1.51	<1-1	1-3	4,600[4]
≥10,000 bbl	0.39	<1	<1-1	15,000[4]

Notes: The number of spills estimated is derived by application of the historical rate of spills per volume crude oil handled (1985-1999) (Anderson and LaBelle, 2000) to the projected production for a proposed action in the WPA or CPA (Table 4-1). Projected production is an estimate of recoverable resource and is influenced by supporting infrastructure, as well as economic and technological factors. The actual number of spills that may occur in the future could vary from the estimated number.

[1] Source: Anderson and LaBelle, 2000.
[2] Source: Table 4-1.
[3] Average spill size.
[4] Median spill size.

Table 3-6

Properties and Persistence by Oil Component Group

Properties and Persistence	Light-weight	Medium-weight	Heavy-weight
Hydrocarbon compounds	Up to 10 carbon atoms	10-22 carbon atoms	>20 carbon atoms
API º	>31.1º	31.1º-22.3 º	<22.3 º
Evaporation rate	Rapid (within 1 day) and complete	Up to several days; not complete at ambient temperatures	Negligible
Solubility in water	High	Low (at most a few mg/L)	Negligible
Acute toxicity	High due to monoaromatic hydrocarbons (BTEX)	Moderate due to diaromatic hydrocarbons (naphthalenes—2 ring PAH's)	Low except due to smothering (i.e., heavier oils may sink)
Chronic toxicity	None, does not persist due to evaporation	PAH components components (e.g., naphthalenes—2 ring PAH's)	PAH components (e.g., phenanthrene, anthracene—3 ring PAH's)
Bioaccumulation potential	None, does not persist due to evaporation	Moderate	Low, may bioaccumulate through sediment sorption
Compositional majority	Alkanes and cycloalkanes	Alkanes that are readily degraded (specify, as done for others)	Waxes, asphaltenes, and polar compounds (not significantly bioavailable or toxic)
Persistence	Low due to evaporation	Alkanes readily degrade, but the diaromatic hydrocarbons are more persistent	High; very low degradation rates and can persist in sediments as tarballs or asphalt pavements

Sources: Michel, 1992; Canadian Center for Energy Information, 2010.

Table 3-7

Estimated Number of Spills that Could Happen in Gulf Coastal Waters
from an Accident Related to Activities Supporting a Proposed Action

Size Category	Assumed Size	WPA Proposed Action	CPA Proposed Action
Total		15-34	49-126
≤1 bbl	1 bbl	12-29	44-114
>1 bbl and <50 bbl	3 bbl	1-2	2-5
≥50 bbl and <1,000 bbl	150 bbl	1-2	2-6
≥1,000 bbl	3,000 bbl	<1-1	<1-1

Note: The estimated number of spills is obtained from the count of coastal spills for 2001 proportioned to reflect that OCS oil comprised 19 percent of the oil crossing into GOM coastal waters in 2001. Intrastate oil and refined product transport were not included. The low estimate in the range was obtained from Dickey (personal communication, 2006) and the high estimate was obtained from aggregated national data available on the Internet (USDOT, Coast Guard, 2001).

Sources: Dickey, personal communication, 2006; USDOT, Coast Guard, 2001; National Ocean Economics Program, 2006; USDOE, Energy Information Administration, 2006.

Table 3-8

Primary Cleanup Options Used during the *Deepwater Horizon* Response

	Fresh Oil	Sheens	Mousse	Tarballs	Burn Residue
On-Water Response	Disperse, skim, burn	Light sheens very difficult to recover, heavier sheens picked up with sorbent boom or sorbent pads	Skim	Snare boom	Manual removal
On-Land Response	Sorbent pads, manual recovery, flushing with water, possible use of chemical shoreline cleaning agents	Light sheens very difficult to recover, heavier sheens picked up with sorbent boom or sorbent pads	Sorbent pads, manual recovery	Snare boom, manual removal, beach cleaning machinery	Manual removal

Source: USDOC, NOAA, 2010a.

Table 3-9

Pipelines* Damaged after 2004-2008 Hurricanes Passing through the WPA and CPA

Hurricane	Total Damage Reports	Pipe and Movement	Platform Connection	Riser	Mudflow	Outside Impact	Unknown
Ivan	168	38	20	67	16	9	18
Katrina	299	61	139	66	1	9	14
Rita	243	31	94	89	0	8	21
Gustav/Ike	314	14	2	273	2	7	16

* Not discriminated by diameter.
Sources: Energo Engineering, 2010; Atkins et al., 2007.

Table 3-10

Causes of Hurricane-Related Pipeline Spills Greater Than 50 Barrels

Hurricane	Amount Spilled (bbl)	Cause
Ivan	1,720	Mudflow
Ivan	671	Movement
Ivan	126	Platform
Ivan	200	Platform
Ivan	250	Platform
Ivan	260	Platform
Ivan	95	Movement
Ivan	123	Movement
Katrina	960	Movement
Katrina	50	Platform
Katrina	55	Riser
Katrina	132	Mudslide
Katrina	50	Movement
Rita	75	Riser
Rita	100	Outside Force
Rita	862	Outside Force/Platform
Rita	67	Platform
Rita	108	Riser
Ike	69	Movement
Ike	108	Riser
Ike	56	Platform
Ike	1,316	Outside Force
Ike	209	Riser
Ike	268	Riser

Source: USDOI, BOEMRE data.

Table 3-11

Total Producing Wells, Total Oil, and Total Gas Production in the Nine Coastal Parishes of Louisiana in 2009

Parish	Total Producing Wells	Total Oil Produced (bbl)	Total Gas Produced (Mcf)
St. Bernard	114	666,757	12,662,442
Plaquemines	1,734	16,870,508	74,737,520
Jefferson	221	1,202,961	11,199,616
Lafourche	539	5,769,795	35,366,426
Terrebonne	569	5,984,437	93,070,163
St. Mary	345	3,400,486	40,127,959
Iberia	172	2,891,805	48,567,357
Vermilion	249	3,062,983	63,928,992
Cameron	323	3,278,189	57,276,938
TOTAL	4,266	43,127,921	436,940,000

Mcf = 1,000 ft^3

bbl = 42 U.S. gal

Source: SONRIS lite database (Louisiana Dept. of Natural Resources, 2010).

Table 3-12

Designated Ocean Dredged-Material Disposal Sites in the Cumulative Impact Area

ODMDS Name	Location Coordinates		Water Depth	Size	Authorized Material, Last Time Used and Amount Disposed
	Latitude	Longitude			
Pensacola Nearshore	30°17'24"N 30°17'00"N 30°15'36"N 30°15'15"N	87°18'30"W 87°19'50"W 87°17'48"W 87°19'18"W	~36 ft, ~11m	2.48 mi^2, 642 ha, 1,587 ac	Medium-grained sand, <10% fines. 1987; 157,100 yd^3
Pensacola Offshore	30°08'50"N 30°08'50"N 30°07'05"N 30°07'05"N	87°19'30"W 87°16'30"W 87°16'30"W 87°19'30"W	65-80 ft 20-24m	6 mi^2, 1,554 ha, 3,840 ac	Primarily fine-grained. 2005; 63,000 yd^3
Mobile	30°10'00"N 30°10'24"N 30°09'24"N 30°08'30"N 30°08'30"N	88°07'42"W 88°05'12"W 88°04'42"W 88°05'12"W 88°08'12"W	~46 ft, ~14m	4.8 mi^2, 1,243 ha, 3,072 ac	Dredged material meeting USEPA Ocean Dumping Criteria. 2008; 2,235,993 yd^3
Pascagoula	30°12'06"N 30°11'42"N 30°08'30"N 30°08'18"N	88°44'30"W 88°33'24"W 88°37'00"W 88°41'54"W	38-52 ft, 11.5-19m	18.5 mi^2, 4,791 ha, 11,840ac	Suitable material from the Mississippi Sound and vicinity. 2008; 1,489,100 yd^3
Gulfport West	30°12'00"N 30°12'00"N 30°11'00"N 30°07'00"N 30°06'36"N 30°10'30"N	89°00'30"W 88°59'30"W 89°00'00"W 88°56'30"W 88°57'00"W 89°00'36"W	~27 ft, ~8.2m	5.2 mi^2, 1,346 ha, 3,328 ac	Dredged material meeting USEPA Ocean Dumping Criteria. 2005; 390,000 yd^3
Gulfport East	30°11'10"N 30°11'12"N 30°07'36"N 30°07'24"N	88°58'24"W 88°57'30"W 88°54'24"W 88°54'48"W	~30 ft, ~9.1m	2.47 mi^2, 640 ha, 1,581 ac	Meet USEPA Ocean Dumping Criteria. 1996; 323,300 yd^3
Mississippi River - Gulf Outlet	29°22'00"N 29°23'00"N 29°24'30"N	88°56'30"W 88°54'30"W 88°52'30"W	20-40 ft, 6-12m	6.03 mi^2, 1,562 ha, 3,859 ac	Dredged material from the vicinity of Mississippi River Gulf Outlet. 2005; 909,100 yd^3
Mississippi River - Southwest Pass	28°53'58"N 28°53'45"N 28°53'13"N 28°53'11"N	89°25'31"W 89°25'09"W 89°25'28"W 89°24'49"W	8-106 ft, 2.7-32.2m	3.44 mi^2, 891 ha, 2,202 ac	Dredged material from the vicinity of the Southwest Pass Channel. 2008; 6,890,400 yd^3
Barataria Bay Waterway	29°13'30"N 29°13'54"N 29°14'21"N	89°53'30"W 89°53'48"W 89°54'06"W	8-20 ft, 2.4-6.1m	1,4 mi^2, 362 ha, 896 ac	Dredged material from the vicinity of Barataria Bay Waterway. 1988; 775,000 yd^3
Houma Navigation Canal (Cat Island Pass)	28°58'09"N 28°58'57"N 28°57'57"N	90°29'30"W 90°31'30"W 90°31'54"W	6-30 ft, 1.8-9.1m	2.08 mi^2, 539 ha, 1,331 ac	Dredged material from the vicinity of Cat Island Pass, Louisiana. 1997; 117,400 yd^3

Table 3-12. Designated Ocean Dredged-Material Disposal Sites in the Cumulative Impact Area (continued).

ODMDS Name	Location Coordinates		Water Depth	Size	Authorized Material, Last Time Used and Amount Disposed
	Latitude	Longitude			
Atchafalaya Bar Channel	29°07'00"N 29°08'00"N 29°09'00"N	91°31'30"W 91°29'00"W 91°27'00"W	~16 ft, ~4.8m	9.14 mi^2, 2,367 ha, 5,850 ac	Dredged material from the bar channel of the Atchafalaya River. 2008; 9,545,800 yd^3
Calcasieu River & Pass	29°30'00"N 29°30'51"N 29°30'00"N	93°10'18"W 93°10'00"W 93°09'27"W	36-46 ft, 11 to 14 m	5.8 mi^2, 1,502 ha, 3,712 ac	Dredged material from the vicinity of the Calcasieu River and Pass Project. 2008; 364,700 yd^3
Sabine-Neches Waterway No. 1 & 2	29°27'30"N 29°27'30"N 29°26'38"N 29°26'38"N	93°37'00"W 93°36'45"W 93°36'45"W 93°37'00"W	25.7-42.6 ft, 9-13m	6.6 mi^2, 1709 ha, 4,224 ac	Dredged material from the Sabine-Neches area. 2006; 1,524,200 yd^3
Sabine-Neches Waterway No. 3 & 4	29°35'52"N 29°35'52"N 29°35'00"N 29°35'00"N	93°41'45"W 93°41'30"W 93°41'30"W 93°41'45"W	16.4-33 ft, 5-10m	8.9 mi^2, 2,305 ha, 5,696 ac	Dredged material from the Sabine-Neches area. 2008; 1,691,900 yd^3
Galveston Harbor & Channel	29°20'22"N 29°19'32"N 29°19'23"N 29°20'13"N	94°37'11"W 94°36'56"W 94°37'06"W 94°37'21"W	33-51 ft, 10-15.5m	6.6 mi^2, 1,709 ha, 4,224 ac	Dredged material from the Galveston, Texas, area. 2008; 2,395,800 yd^3
Freeport Harbor, New Work	28°54'28"N 28°54'35"N 28°55'07"N 28°54'60"N	95°13'40"W 95°13'28"W 95°14'01"W 95°14'13"W	54-61 ft, 16.4-18.6m	2.64 mi^2, 684 ha, 1,690 ac	Dredged material from the Freeport Harbor Entrance and Jetty Channels, Texas. 1992; 46,800 yd^3
Matagorda Ship Channel	28°24'27"N 28°24'33"N 28°25'10"N 28°25'04"N	96°16'04"W 96°15'52"W 96°16'30"W 96°16'42"W	25-40 ft, 7.5-12.2m	0.56 mi^2, 145 ha, 358 ac	Dredged material from the Matagorda Ship Channel, Texas. 2006; 336,700 yd^3
Corpus Christi Ship Channel	27°50'10"N 27°50'20"N 27°50'48"N 27°50'38"N	96°59'17"W 96°59'09"W 96°59'57"W 97°00'05"W	35-50 ft, 10.6-15.2m	0.63 mi^2, 163 ha, 403 ac	Dredged material from the Corpus Christi Ship Channel, Texas. 2007; 954,600 yd^3
Port Mansfield	26°32'11"N 26°31'58"N 26°31'58"N 26°32'11"N	97°13'44"W 97°13'44"W 97°14'42"W 97°14'42"W	35-50 ft, 10.6-15.2m	0.42 mi^2, 109 ha, 269 ac	Dredged material from the Port Mansfield Entrance Channel, Texas. 1986; 104,200 yd^3
Brazos Island Harbor	26°02'18"N 26°02'18"N 26°02'05"N 26°02'05"N	96°06'30"W 97°07'26"W 97°07'26"W 96°06'30"W	55-65 ft, 16.7-19.8m	0.42 mi^2, 109 ha, 269 ac	Dredged material from the Brazos Island Harbor Entrance Channel, Texas. 1997; 350,900

~ approximately.
Sources: National Archives and Records Administration, 2010; U.S. Dept. of the Army, COE, 2011.

Table 3-13

Projected OCS Sand Borrowing Needs for Planned Restoration Projects

Restoration Project	Maximum Sand (yd3)	Source (OCS Area and Block) (if known)
Pelican Island (CWPPRA BA-35)	~5,500,000	West Delta (Sandy Point site)
Raccoon Island (CWPPRA TE-48)	750,000 to 830,000	Ship Shoal 64 & 71
Cameron Parish Shoreline	~10,000,000	Sabine Bank
Point Au Fer Shoreline	N/A	N/A
LCA Terrebonne Basin		
Raccoon Island	~8,340,000	Ship Shoal 88 & 89; South Pelto 12 & 13
Whiskey Island	~7,720,000	Ship Shoal 88 & 89; South Pelto 12 & 13
Trinity and East Islands	~16,260,000	Ship Shoal 88 & 89; South Pelto 12 & 13
Timbalier Island	~10,700,000	Ship Shoal 88 & 89; South Pelto 12 & 13
East Timbalier Island	~11,230,000	N/A
LCA Barataria Basin		
Caminada Headland	~6,000,000	South Pelto 12 &13
TOTAL	~76,500,000	

N/A = not available
~ approximately

Table 3-14

Vessel Calls at U.S. Gulf Coast Ports in 2004 and 2009

Vessel Type	2004 Percent of Total Calls in U.S.	2009 Percent of Total Calls in U.S.
Tanker	52.4	55.8
Container	7.0	9.0
Dry Bulk	42.6	46.8
RO-RO (Roll-on Roll-off)	7.0	9.9
Gas	59.8	62.6
Combo	56.2	75.6
General	28.8	39.0
All Types	31.2	34.1

Source: USDOT, MARAD, 2009.

Table 3-15

Designated Louisiana Service Bases Identified in Applications for Pipelines, Exploration, and Development Plans between 2003 and 2008 and Miles of Navigation Canal Bordered by Saline, Brackish Water, and Freshwater Wetlands

Shore Base	Number of Pipeline Applications with Designated Service Base		Number of Exploration and Development Plans with Designated Service Base		Miles Bordering Salt and Brackish Wetlands	Miles Bordering Fresh Wetlands
	2003-2008	Percent	2003-2008	Percent		
Fourchon	303	31.5	618	44.4	0**	0**
Cameron	247	25.7	383	27.5	0	0
Intracoastal City	102	10.6	94	6.7	6.4	0
Venice	96	10.0	139	9.9	Miss. River	0
Morgan City	68	7.1	52	3.7	Miss. River	0
Leeville	37	3.9	18	1.3	0	0
Grand Isle	29	3.0	2	0.1	0	0
Dulac	20	2.1	8	0.6	1.7	0
Berwick	14	1.5	19	1.4	Miss. River	0
Lake Charles	12	1.2	1	0.1	3.4	0
Freshwater City	10	1.0	18	1.3	0	0
Houma	8	0.8	18	1.3	5.3	6.6
Amelia	2	0.2	7	0.5	0	0
Galliano	1	0.1	7	0.5	0	0
Boothville	3	0.3	6	0.4	Miss. River	0
Abbeville	7	0.7	0	0.0	0	0
Grand Chenier	2	0.2	1	0.1	0	0
Grand Total	961	99.9	1,391	99.8	16.8	6.6

*= compiled by BOEMRE staff using operator-designated service bases from OCS plans and pipeline applications.
**= "0" indicates the service base has no surrounding wetlands in the category.

Table 3-16

Coastal Impact Assistance Program Allocations for all Eligible States ($)

Recipient	FY 2007	FY 2008	FY 2009	FY 2010	Total
Alabama	25,551,607.04	25,551,607.04	19,728,257.36	19,524,845.48	90,356,316.92
State Share	16,608,544.58	16,608,544.58	12,823,367.28	12,691,149.56	58,731,606.00
County Share	8,943,062.46	8,943,062.46	6,904,890.08	6,833,695.92	31,624,710.92
Alaska	2,425,000.00	2,425,000.00	37,471,876.48	37,085,568.47	79,407,444.95
State Share	1,576,250.00	1,576,250.00	24,356,719.71	24,105,619.51	51,614,839.22
Borough Share	848,750.00	848,750.00	13,115,156.77	12,979,948.97	27,792,605.74
California	7,444,441.75	7,444,441.75	4,923,124.98	4,872,363.83	24,684,372.31
State Share	4,838,887.13	4,838,887.13	3,200,031.24	3,167,036.49	16,044,841.99
County Share	2,605,554.61	2,605,554.61	1,723,093.74	1,705,327.34	8,639,530.30
Louisiana	127,547,898.57	127,547,898.57	120,911,588.83	119,663,560.77	495,670,946.74
State Share	82,906,134.07	82,906,134.07	78,592,532.74	77,781,314.50	322,186,115.38
Parish Share	44,641,764.50	44,641,764.50	42,319,056.09	41,882,246.27	173,484,831.36
Mississippi	30,939,850.55	30,939,850.55	23,819,815.26	23,574,217.72	109,273,734.08
State Share	20,110,902.86	20,110,902.86	15,482,879.92	15,323,241.52	71,027,927.16
County Share	10,828,947.69	10,828,947.69	8,336,935.34	8,250,976.20	38,245,806.92
Texas	48,591,202.09	48,591,202.09	35,645,337.09	35,279,443.73	168,107,185.00
State Share	31,584,281.36	31,584,281.36	23,169,469.11	22,931,638.42	109,269,670.25
County Share	17,006,920.73	17,006,920.73	12,475,867.98	12,347,805.30	58,837,514.74

Table 3-17

Coastal Impact Assistance Program Grants Status for Gulf of Mexico States ($)

Recipient	Total Allocation	Amount Applied For	Amount Awarded	Amount Under Review	Allocation Balance
Alabama	90,356,316.92	26,371,168.00	17,665,845.59	8,705,322.41	63,985,148.92
State	58,731,606.00	13,408,368.07	10,576,735.04	2,831,633.03	45,323,237.93
County	31,624,710.92	12,962,799.93	7,089,110.55	5,873,689.38	18,661,910.99
Louisiana	495,670,946.74	167,570,557.69	151,147,595.40	16,422,962.29	328,100,389.05
State	322,186,115.38	114,414,404.38	109,013,629.00	5,400,775.38	207,771,711.00
Parish	173,484,831.36	53,156,153.31	42,133,966.40	11,022,186.91	120,328,678.05
Mississippi	109,273,734.08	41,527,869.50	32,065,439.00	9,462,430.50	67,745,864.58
State	71,027,927.16	33,239,105.50	30,083,154.00	3,155,951.50	37,788,821.66
County	38,245,806.92	8,288,764.00	1,982,285.00	6,306,479.00	29,957,042.92
Texas	168,107,185.00	25,091,736.63	22,005,691.30	3,086,045.33	143,015,448.36
State	109,269,670.25	19,627,047.36	18,627,047.36	1,000,000.00	89,642,622.89
County	58,837,514.74	5,464,689.27	3,378,643.94	2,086,045.33	53,372,825.47
Total GOM	863,408,182.74	260,561,331.82	222,884,571.29	37,676,760.53	602,846,850.91

Table 3-18

Hurricane Landfalls in the Northern Gulf of Mexico
from 1995 to 2010

Event	Year	Impacted State	Storm Name	Intensity at Landfall
1	1995	AL, FL	Opal	Hurricane Category 3
2	1995	FL	Erin	Hurricane Category 2
3	1997	LA, AL	Danny	Hurricane Category 1
4	1998	FL	Earl	Hurricane Category 1
5	1998	MS, AL	Georges	Hurricane Category 2
6	1999	TX	Bret	Hurricane Category 3
7	2002	LA	Lili	Hurricane Category 1
8	2003	TX	Claudette	Hurricane Category 1
9	2004	MS, AL	Ivan	Hurricane Category 4
10	2005	LA, MS	Cindy	Hurricane Category 1
11	2005	FL, AL	Dennis	Hurricane Category 3
12	2005	LA, MS	Katrina	Hurricane Category 5
13	2005	TX, LA	Rita	Hurricane Category 3
14	2007	TX, LA	Humberto	Hurricane Category 1
15	2008	LA	Gustav	Hurricane Category 2
16	2008	TX, LA	Ike	Hurricane Category 4
17	2008	TX	Dolly	Hurricane Category 1

* No hurricane landfalls in the northern Gulf of Mexico in 2009 or 2010.
Source: USDOC, NOAA, 2010b.

Table 3-19

OCS Facility Damage after the 2004-2008 Hurricanes in the WPA and CPA

Storm	Platforms Exposed to High Winds (≥73 mph)	Platforms		Damaged Pipelines (≥10 in)
		Destroyed	Damaged	
Ivan (2004)	150	7	14	13
Katrina (2005)	3,050*	43	NR	40
Rita (2005)		69	NR	101
Gustav (2008)	677	1	40	NR
Ike (2008)	2,127	60	124	NR

NR = not reported.
*Combined totals for both Hurricanes Katrina and Rita.
Statistics compiled from BOEMRE website and press releases.

Table 4-1

National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour (1)	None	
	35 ppm (40 mg/m^3)	1-hour (1)		
Lead	0.15 µg/m^3 (2)	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m^3	Quarterly Average	Same as Primary	
Nitrogen Dioxide	53 ppb (3)	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour (4)	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour (5)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual (6) (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour (7)	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour (8)	Same as Primary	
	0.08 ppm (1997 std)	8-hour (9)	Same as Primary	
	0.12 ppm	1-hour (10)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour (1)
	0.14 ppm	24-hour (1)		
	75 ppb (11)	1-hour	None	

(1) Not to be exceeded more than once per year.
(2) Final rule signed October 15, 2008.
(3) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.
(4) To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
(5) Not to be exceeded more than once per year on average over 3 years.
(6) To attain this standard, the 3-year average of the weighted annual mean $PM^{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
(7) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
(8) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).
(9) (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as USEPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(c) USEPA is in the process of reconsidering these standards (set in March 2008).
(10) (a) USEPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤1.
(11) (a) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

Table 4-2

Estimated Abundance of Cetaceans
in the Northern Gulf of Mexico Oceanic Waters

Species	Common Name	Estimated Number of Individuals
Balaenoptera edeni	Bryde’s whale	15
Physeter macrocephalus	Sperm whale*	1,665
Kogia spp.	Dwarf and Pygmy sperm whale	453
Ziphius cavirostris	Cuvier’s beaked whale	65
Mesoplodon sp.	Blainville’s and Gervais’ beaked whale	57
Feresa attenuata	Pygmy killer whale	323
Pseudorca crassidens	False killer whale	777
Orcinus orca	Killer whale	49
Globicephala sp.	Pilot whale, short-finned	716
Peponocephala electra	Melon-headed whale	2,283
Grampus griseus	Risso’s dolphin	1,589
Tursiops truncatus	Bottlenose dolphin	3,708
Steno bredanensis	Rough-toothed dolphin	unknown
Lagenodelphis hosei	Fraser’s dolphin	unknown
Stenella frontalis	Atlantic spotted dolphin	unknown
Stenella longirostris	Spinner dolphin	1,989
Stenella attenuate	Pantropical spotted dolphin	34,067
Stenella clymene	Clymene dolphin	6,575
Stenella coeruleoalba	Striped dolphin	3,325

*Endangered.
Source: Waring et al., 2009.

Table 4-3

Sea Turtle Taxa of the Northern Gulf of Mexico

Order Testudines (turtles)	Relative Occurrence	ESA Status
Family Cheloniidae (hardshell sea turtles)		
Loggerhead sea turtle (*Caretta caretta*)	C	T
Green sea turtle (*Chelonia mydas*)	C	T/E
Hawksbill sea turtle (*Eretmochelys imbricata*)	R	E
Kemp's ridley sea turtle (*Lepidochelys kempii*)	C	E
Family Dermochelyidae (leatherback sea turtle)		
Leatherback sea turtle (*Dermochelys coriacea*)	U	E

Population status in the northern Gulf is summarized according to the following categories:

COMMON (C): A common species is one that is abundant wherever it occurs in the region (i.e., the northern Gulf). Most common species are widely distributed over the area.

UNCOMMON (U): An uncommon species may or may not be widely distributed but does not occur in large numbers. Uncommon species are not necessarily rare or endangered.

RARE (R): A rare species is one that is present in such small numbers throughout the region that it is seldom seen. Although not threatened with extinction, a rare species may become endangered if conditions in its environment change.

Endangered Species Act (ESA) status is summarized according to listing status under the following categories:

ENDANGERED (E): Species determined to be in imminent danger of extinction throughout all of a significant portion of their range.

THREATENED (T): Species determined likely to become endangered in the foreseeable future.

Table 4-4

Comparison of Oil Spills by Type, Location, Year, and Volume (in U.S. gallons) and Their Relative Impacts to Birds based on Surveys and Modeling[a]

Incident	Type	Location	Year	Volume[b,c]	Bird Surveys[d]	Estimated Mortality[e]	Reference[f]
Ixtoc	Blowout	Mexico	1979	145.6 million	>3,000	No research or models*	1
Exxon Valdez	Tanker	Alaska, USA	1989	10.8 million	>30,000	100,000-645,000	2, 3, 4, 5
Sea Empress	Tanker	Wales, UK	1996	22.1 million	>4,500	No research or models	6, 7
M/V *Citrus*	Tanker	Alaska, USA	1996	Unknown	>1,000	1,930	8
Erika	Tanker	France	1999	6.1 million	>74,000	80,000-150,000	9, 10
Prestige	Tanker	Spain	2002	19.2 million	>9,000	115,000-300,000	11, 12, 13, 14, 15, 16
Terra Nova	Rig	Newfoundland, CAN	2004	42,000	No survey	3,593-16,122	17
M/V *Selendang Ayu*	Tanker	Alaska, USA	2004	354,218	1,603	Pending**	2, 18
Black Sea	Tanker	Kerch Strait, RUS	2007	1.47 million	>30,000	No research or models	19
Deepwater Horizon	Blowout	Louisiana, USA	2010	210 million	8,000	Pending**	20, 21

[a] Since the *Exxon Valdez* oil spill in March 1989, but including the *Ixtoc I* blowout in the Bay of Campeche, Mexico (1979; Jernelöv, 2010). Refer to Tables 1-5 in Helm et al. (2008) for additional information. Includes oil spills associated with tankers, barges, wells, rigs-platforms, and blowouts in which bird mortality data are available. This list of spills is not exhaustive but reflects a representative cross-section of oil-spill events across the world over the last ≥20 years. For a more comprehensive review of oil spills, locations, spill volumes, and bird mortality, refer to Burger (1993, Table 1), Castege et al. (2007, Table 2), Helm et al. (2008, Tables 1-6), and Tan et al. (2010, Table 1).

[b] Volume estimates are in gallons.

[c] Volume estimates were in some cases converted from figures cited in a specific reference using the conversion of metric tons to gallons of 7.3 bbl/ton and 42 gal/bbl (Wilhelm et al., 2007, p. 540). In other cases, the figures were pulled from the Tables in Helm et al. (2008). NOTE: Spill volume tends to be a poor predictor of bird mortality associated with an oil spill (Burger, 1993), although it should be considered for inclusion in any models to estimate total bird mortality, preferably with some metric of species composition and abundance (preferably density) pre-spill (Wilhelm et al., 2007).

[d] Figures cited in specific references usually as a part of the damage assessment process including beached-bird surveys, boat or ship-based surveys, or aerial surveys to collect dead or oiled birds. It has been well documented that, in most cases, survey efforts to collect bird carcasses represents a small fraction of the total mortality for a given oil-spill event. That is, the recovery rate of oiled carcasses is biased low; Burger (1993) and Wiese and Jones (2001), using different methodologies, arrived at recovery rate estimates of only 20%. Piatt and Ford (1996) derived a recovery mean rate estimate of only 17% (range 0.0%-59.0%) based on 17 different studies spanning 21 years (1970-1991).

[e] Final estimated mortality typically includes results from drift and carcass experiments plus modeling efforts to account for birds oiled, but ‘unavailable’ to be detected; that is, a correction for detection and scavenging bias, deposition and persistence rates, and the effects of wind, currents, weather, topography, and habitat. Refer to Flint and Fowler (1998), Flint et al. (1999), Castège et al. (2007), Wilhelm et al. (2007), Byrd et al. (2009), and other references herein for additional information regarding biases associated with mortality estimates from carcass surveys only.

[f] Most of the references used herein are from the peer-reviewed scientific literature.

Table 4-4. Comparison of Oil Spills by Type, Location, Year, and Volume (in U.S. gallons) and Their Relative Impacts to Birds based on Surveys and Modeling[a] (continued).

[*] Literature searches on the Internet revealed only two avian-related references as a result of the *Ixtoc I* oil spill: Chapman, 1981 and 1984.
[**] Pending results of the NRDA process and litigation regarding damage claims against litigants; see also Helm et al., 2006 and 2008.
[1] Jernelöv, 2010.
[2] Helm et al., 2006.
[3] Helm et al., 2008.
[4] Ford et al., 1996.
[5] Piatt and Ford, 1996.
[6] Banks et al., 2008.
[7] Law and Kelley, 2004.
[8] Flint et al., 1999.
[9] Cadiou et al., 2004.
[10] Castège et al., 2004.
[11] Castège et al., 2007.
[12] Alonso-Alvarez et al., 2007.
[13] Munilla and Velando, 2010.
[14] Velando et al., 2005a.
[15] Velando et al., 2005b.
[16] Camphuysen et al., 2002.
[17] Wilhelm et al., 2007.
[18] Byrd et al., 2009.
[19] Tan et al., 2010.
[20] USDOI, FWS, 2010.
[21] Oil Spill Commission, 2010.

Table 4-5

Relative Oiling Ranks for Various Avian Species Groupings Collected Post-*Deepwater Horizon* Event in the Gulf of Mexico[a]

Species Group	# Representative Spp.[1]	# Collected	# Oiled	Oiling Rate (% ± SE)[2]	Oiling Rank[3]
Diving*	5	182	102	0.50 ± 0.19	1
Seabirds*	25	5946	2512	0.37 ± 0.05	2
Shorebirds*	13	97	24	0.13 ± 0.06	6
Passerines*	21	77	17	0.20 ± 0.07	5
Marsh/Wading*	21	424	117	0.24 ± 0.05	4
Waterfowl*	11	56	16	0.37 ± 0.13	3
Raptors*	6	16	3	0.05 ± 0.05	7

a Data obtained from the U.S. Fish and Wildlife Service (FWS) as summarized a table dated November 30, 2010. The data used in this table are verified as per the FWS QA/QC processes. Disclaimer: All data should be considered provisional, incomplete, and subject to change. For more information, see USDOI, FWS, 2010.

* Species Group: As defined in the text of this Supplemental EIS. As of November 30, 2010, 8,000 individuals of 102 species had been collected and identified by FWS. Six new species were added since the November 16th summary. NOTE: The Top 5 most-impacted species are all representative of the “seabirds” group, with an oiling rate (0.44) above the combined average of all species, including “unknowns” and “other” (0.27).

1 Represents the actual number of birds identified to the species level for each of the Species Groups; reflects sample size for determining mean Oiling Rate. This number should be fairly representative of the suite of species available to be oiled. However, this number is dependent on efforts to correctly assign species to unidentified birds or unknowns, which is also a function of the search effort. The search effort has likely declined dramatically since the *Deepwater Horizon* was plugged/capped.

2 Oiling Rate: For each species, an oiling rate was calculated by dividing the “total” number of oiled individuals (∑ alive + dead) /∑ of individuals collected for a given species/row. These rates were then used to calculate summary statistics. In general, it has been well documented that the number of birds collected after a spill event represents a small fraction of the total oiled population (direct mortality) due to various factors: species-specific differences in vulnerability to spilled oil; species-specific differences in distribution, habitat use, and behavior; species-specific differences in abundance; species-specific differences in carcass deposition rates, persistence rates, and detection probabilities; overall search effort and temporal and spatial variation in search effort; and carcass loss due to predation, habitat, weather, tides, and currents (Piatt et al., 1990a and 1990b; Ford et al., 1996; Piatt and Ford, 1996; Fowler and Flint, 1997; Flint and Fowler, 1998; Flint et al., 1999; Castege et al., 2007; Byrd et al., 2009; Flint et al., 2010). For example, Piatt and Ford (1996, Table 1) estimated a mean carcass recovery rate of only 17% for a number of previous oil-bird impact studies. Burger (1993) and Wiese and Jones (2001) estimated recovery rates of 20%, with the latter study based on a drift-block design to estimate carcass recovery rate from beached-bird surveys. NOTE: Spill volume tends to be a poor predictor of bird mortality associated with an oil spill (Burger, 1993), although it should be considered for inclusion in any models to estimate total bird mortality, preferably with some metric of species composition and abundance (preferably density) pre-spill (Wilhelm et al., 2007). For this table, the value obtained for passerines and raptors is almost certainly biased high due to the small sample sizes (several cases where only 1-2 birds/species) for individual species and due to the influence of high estimates for oiling (100%). For the other Species Groups, e.g., shorebirds, the value obtained is likely biased low due the larger number of species with several instances where only one bird was collected and it did not meet the criteria to be designated as oiled. There was a significant difference ($F = 20.80$, $df = 1, 12$; $P = 0.0006$) in oiling rates among species.

3 Oiling Rank: Reflects the relative rank of a given Species Group as a function of the mean Oiling Rate. As expected, diving birds and seabirds had the highest oiling rate of any of the Species Groups (King and Sanger, 1979; Wiens et al., 1984; Piatt et al., 1990a; Williams et al., 1995) due to their reliance on offshore habitat for foraging and as a substrate for resting, preening, and other maintenance behaviors.

Table 4-6

Birds Collected and Summarized by the U.S. Fish and Wildlife Service Post-*Deepwater Horizon* Event in the Gulf of Mexico[a, b]

Common Name	Species Group*	Grand Total	Visibly Oiled		Total	Not Visibly Oiled		Total	Unknown Oiling		Total	Oiling Rate[1,2]
			Dead	Alive		Dead	Alive		Dead	Alive		
American Coot	Marsh/Wading	5	2	2	4	0	0	0	1	0	1	0.80
American Oystercatcher	Shorebird	17	7	3	10	3	3	6	1	0	1	0.59
American Redstart	Passerine	1	0	0	0	1	0	1	0	0	0	0.00
American White Pelican	Seabird	17	2	0	2	2	6	8	7	0	7	0.12
Audubon's Shearwater	Seabird	6	1	1	2	2	2	4	0	0	0	0.33
Barn Owl	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Barn Swallow	Passerine	1	1	0	1	0	0	0	0	0	0	1.00
Belted Kingfisher	Passerine	2	0	0	0	1	1	2	0	0	0	0.00
Black-crowned Night Heron	Marsh/Wading	22	6	3	9	7	5	12	1	0	1	0.41
Black Oystercatcher	Shorebird	1	0	0	0	1	0	1	0	0	0	0.00
Black Skimmer	**Seabird**	**263**	**51**	**16**	**67**	**141**	**14**	**155**	**41**	**0**	**41**	**0.25**
Black Tern	Seabird	12	1	0	1	7	3	10	1	0	1	0.08
Black-bellied Whistling Duck	Waterfowl	2	0	0	0	0	2	2	0	0	0	0.00
Black-necked Stilt	Shorebird	3	0	0	0	3	0	3	0	0	0	0.00
Blue-winged Teal	Waterfowl	3	0	0	0	3	0	3	0	0	0	0.00
Boat-tailed Grackle	Passerine	2	0	0	0	1	1	2	0	0	0	0.00
Brown Pelican	**Seabird**	**911**	**136**	**210**	**346**	**225**	**146**	**371**	**194**	**0**	**194**	**0.38**
Brown-headed Cowbird	Passerine	1	0	0	0	0	1	1	0	0	0	0.00
Bufflehead	Waterfowl	1	0	1	1	0	0	0	0	0	0	1.00
Canada Goose	Waterfowl	4	0	1	1	1	2	3	0	0	0	0.25
Caspian Tern	Seabird	20	7	2	9	5	4	9	2	0	2	0.45
Cattle Egret	Marsh/Wading	32	1	1	2	21	4	25	5	0	5	0.06
Clapper Rail	Marsh/Wading	128	27	5	32	63	12	75	21	0	21	0.25
Common Loon	Diving	106	33	27	60	22	20	42	4	0	4	0.57
Common Moorhen	Marsh/Wading	4	1	0	1	3	0	3	0	0	0	0.25
Common Nighthawk	Passerine	1	0	0	0	0	1	1	0	0	0	0.00
Common Tern	Seabird	32	13	9	22	8	1	9	1	0	1	0.69
Common Yellowthroat	Passerine	2	0	0	0	2	0	2	0	0	0	0.00
Cooper's Hawk	Raptor	1	0	0	0	0	1	1	0	0	0	0.00
Cory's Shearwater	Seabird	1	0	0	0	0	1	1	0	0	0	0.00
Double-crested Cormorant	Diving	25	2	1	3	13	7	20	2	0	2	0.12
Eastern Kingbird	Passerine	2	1	0	1	1	0	1	0	0	0	0.50
Eastern Meadowlark	Passerine	1	0	0	0	1	0	1	0	0	0	0.00

Table 4-6. Birds Collected and Summarized by the U.S. Fish and Wildlife Service Post-*Deepwater Horizon* Event in the Gulf of Mexico[a, b] (continued).

Common Name	Species Group*	Grand Total	Visibly Oiled		Total	Not Visibly Oiled		Total	Unknown Oiling		Total	Oiling Rate[1,2]
			Dead	Alive		Dead	Alive		Dead	Alive		
Eurasian Collared-Dove	Passerine	1	0	0	0	1	0	1	0	0	0	0.00
European Starling	Passerine	2	0	1	1	1	0	1	0	0	0	0.50
Forster's Tern	Seabird	52	16	8	24	13	9	22	6	0	6	0.46
Fulvous Whistling Duck	Waterfowl	1	0	0	0	0	1	1	0	0	0	0.00
Glossy Ibis	Marsh/Wading	2	0	0	0	1	0	1	1	0	1	0.00
Great Blue Heron	Marsh/Wading	50	5	2	7	23	16	39	4	0	4	0.14
Great Egret	Marsh/Wading	33	6	6	12	10	3	13	8	0	8	0.36
Great-horned Owl	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Greater Shearwater	Seabird	28	7	4	11	12	4	16	1	0	1	0.39
Green Heron	Marsh/Wading	18	2	0	2	9	6	15	1	0	1	0.11
Gull-billed Tern	Seabird	8	0	0	0	2	4	6	2	0	2	0.00
Herring Gull	Seabird	42	8	8	16	9	13	22	4	0	4	0.38
Horned Grebe	Diving	1	0	1	1	0	0	0	0	0	0	1.00
House Sparrow	Passerine	2	0	0	0	1	1	2	0	0	0	0.00
Killdeer	Shorebird	3	0	0	0	3	0	3	0	0	0	0.00
King Rail	Marsh/Wading	1	0	0	0	0	1	1	0	0	0	0.00
Laughing Gull	**Seabird**	**3339**	**968**	**341**	**1309**	**1341**	**365**	**1706**	**323**	**1**	**324**	**0.39**
Least Bittern	Marsh/ Wading	6	0	0	0	4	2	6	0	0	0	0.00
Least Tern	Seabird	110	45	6	51	40	6	46	13	0	13	0.46
Lesser Black-backed Gull	Seabird	5	1	1	2	0	1	1	2	0	2	0.40
Lesser Scaup	Waterfowl	1	0	0	0	0	0	0	1	0	1	0.00
Little Blue Heron	Marsh/Wading	6	0	0	0	4	1	5	1	0	1	0.00
Long-billed Dowitcher	Shorebird	1	0	0	0	0	1	1	0	0	0	0.00
Magnificant Frigatebird	Seabird	9	3	2	5	1	1	2	2	0	2	0.56
Mallard	Waterfowl	31	5	4	9	15	7	22	0	0	0	0.29
Manx Shearwater	Seabird	1	1	0	1	0	0	0	0	0	0	1.00
Masked Booby	Seabird	12	4	3	7	1	4	5	0	0	0	0.58
Mottled Duck	Waterfowl	6	0	0	0	5	0	5	1	0	1	0.00
Mourning Dove	Passerine	17	2	1	3	8	6	14	0	0	0	0.18
Neotropic Cormorant	Diving	3	0	0	0	1	0	1	2	0	2	0.00
Northern Cardinal	Passerine	3	0	0	0	3	0	3	0	0	0	0.00
Northern Gannet	**Seabird**	**632**	**221**	**187**	**408**	**89**	**103**	**192**	**31**	**1**	**32**	**0.65**
Northern Mockingbird	Passerine	4	0	0	0	3	1	4	0	0	0	0.00
Osprey	Raptor	11	2	1	3	5	3	8	0	0	0	0.27
Pied-billed Grebe	Diving	47	14	24	38	5	3	8	1	0	1	0.81
Piping Plover	Shorebird	1	0	0	0	1	0	1	0	0	0	0.00

Table 4-6. Birds Collected and Summarized by the U.S. Fish and Wildlife Service Post-*Deepwater Horizon* Event in the Gulf of Mexico[a, b] (continued).

Common Name	Species Group[*]	Grand Total	Visibly Oiled		Total	Not Visibly Oiled		Total	Unknown Oiling		Total	Oiling Rate[1,2]
			Dead	Alive		Dead	Alive		Dead	Alive		
Purple Gallinule	Marsh/Wading	1	0	0	0	1	0	1	0	0	0	0.00
Purple Martin	Passerine	5	1	0	1	3	1	4	0	0	0	0.20
Red-breasted Merganser	Waterfowl	4	1	1	2	1	1	2	0	0	0	0.50
Reddish Egret	Marsh/Wading	4	1	1	2	1	1	2	0	0	0	0.50
Red-shouldered Hawk	Raptor	1	0	0	0	0	1	1	0	0	0	0.00
Red-tailed Hawk	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Red-winged Blackbird	Passerine	1	0	0	0	1	0	1	0	0	0	0.00
Ring-billed Gull	Seabird	2	0	1	1	1	0	1	0	0	0	0.50
Rock Dove (pigeon)	Passerine	19	2	2	4	4	9	13	2	0	2	0.21
Roseate Spoonbill	Marsh/Wading	18	7	2	9	3	1	4	5	0	5	0.50
Royal Tern	**Seabird**	**348**	**116**	**66**	**182**	**95**	**49**	**144**	**22**	**0**	**22**	**0.52**
Ruddy Duck	Waterfowl	1	1	0	1	0	0	0	0	0	0	1.00
Ruddy Turnstone	Shorebird	18	1	3	4	8	5	13	1	0	1	0.22
Sanderling	Shorebird	32	4	2	6	17	6	23	3	0	3	0.19
Sandwich Tern	Seabird	90	26	19	45	23	13	36	9	0	9	0.50
Seaside Sparrow	Passerine	6	4	0	4	2	0	2	0	0	0	0.67
Semipalm. Sandpiper	Shorebird	2	1	0	1	0	0	0	1	0	1	0.50
Short-billed Dowitcher	Shorebird	1	0	0	0	1	0	1	0	0	0	0.00
Snowy Egret	Marsh/Wading	30	10	8	18	7	3	10	2	0	2	0.60
Sooty Shearwater	Seabird	1	0	0	0	0	1	1	0	0	0	0.00
Sooty Tern	Seabird	4	0	1	1	2	1	3	0	0	0	0.25
Sora	Marsh/Wading	6	2	1	3	1	0	1	2	0	2	0.50
Spotted Sandpiper	Shorebird	1	0	0	0	1	0	1	0	0	0	0.00
Surf Scoter	Waterfowl	2	1	1	2	0	0	0	0	0	0	1.00
Tri-colored Heron	Marsh/Wading	34	9	5	14	7	2	9	11	0	11	0.41
Virginia Rail	Marsh/Wading	4	0	0	0	3	1	4	0	0	0	0.00
White Ibis	Marsh/Wading	11	1	1	2	4	3	7	2	0	2	0.18
White-winged Dove	Passerine	2	0	0	0	1	1	2	0	0	0	0.00
Willet	Shorebird	15	2	1	3	7	3	10	2	0	2	0.20
Wilson's Plover	Shorebird	2	0	0	0	1	0	1	1	0	1	0.00
Wilson's Storm Petrel	Seabird	1	0	0	0	0	1	1	0	0	0	0.00
Yellow-billed Cuckoo	Passerine	2	2	0	2	0	0	0	0	0	0	1.00
Yellow-crowned Night Heron	Marsh/Wading	9	0	0	0	7	2	9	0	0	0	0.00
Unid. Blackbird	Passerine	1	0	0	0	0	1	1	0	0	0	0.00
Unid. Cormorant	Diving	14	3	0	3	10	0	10	1	0	1	0.21
Unid. Dowitcher	Shorebird	5	2	0	2	1	2	3	0	0	0	0.40

Table 4-6. Birds Collected and Summarized by the U.S. Fish and Wildlife Service Post-*Deepwater Horizon* Event in the Gulf of Mexico[a, b] (continued).

Common Name	Species Group[*]	Grand Total	Visibly Oiled		Total	Not Visibly Oiled		Total	Unknown Oiling		Total	Oiling Rate[1,2]
			Dead	Alive		Dead	Alive		Dead	Alive		
Unid. Duck	Waterfowl	4	0	0	0	2	1	3	1	0	1	0.00
Unid. Egret	Marsh/Wading	11	2	0	2	7	0	7	2	0	2	0.18
Unid. Flycatcher	Passerine	1	1	0	1	0	0	0	0	0	0	1.00
Unid. Grackle	Passerine	1	1	0	1	0	0	0	0	0	0	1.00
Unid. Grebe	Diving	6	4	0	4	2	0	2	0	0	0	0.67
Unid. Gull	Seabird	253	79	3	82	131	7	138	33	0	33	0.32
Unid. Hawk	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Unid. Heron	Marsh/Wading	14	5	0	5	6	1	7	2	0	2	0.36
Unid. Loon	Diving	9	2	2	4	4	1	5	0	0	0	0.44
Unid. Mockingbird	Passerine	2	0	0	0	1	1	2	0	0	0	0.00
Unid. Owl	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Unid. Passerine	Passerine	1	0	0	0	1	0	1	0	0	0	0.00
Unid. Pelican	Seabird	26	5	1	6	15	1	16	4	0	4	0.23
Unid. Pigeon	Passerine	17	2	1	3	6	7	13	1	0	1	0.18
Unid. Rail	Marsh/ Wading	4	1	0	1	3	0	3	0	0	0	0.25
Unid. Raptor	Raptor	1	0	0	0	1	0	1	0	0	0	0.00
Unid. Sandpiper	Shorebird	4	0	0	0	2	2	4	0	0	0	0.00
Unid. Shearwater	Seabird	4	0	0	0	3	0	3	1	0	1	0.00
Unid. Shorebird	Shorebird	3	2	0	2	0	0	0	1	0	1	0.67
Unid. Skimmer	Seabird	6	0	0	0	6	0	6	0	0	0	0.00
Unid. Sparrow	Passerine	3	0	0	0	1	0	1	2	0	2	0.00
Unid. Swallow	Passerine	1	0	0	0	1	0	1	0	0	0	0.00
Unid. Tern	Seabird	129	37	1	38	72	1	73	18	0	18	0.29
Unknown spp.		561	51	2	53	420	3	423	85	0	85	0.09
Other		119	33	4	37	58	16	74	8	0	8	0.31
Column Totals		8,000	2,024	1,011	3,035	3,108	948	4056	907	2	909	0.27

[a] Data obtained from the U.S. Fish and Wildlife Service (FWS) as a summarized table dated November 30, 2010. The data used in this table are verified as per the FWS QA/QC processes. Disclaimer: All data should be considered provisional, incomplete, and subject to change. For more information, see USDOI, FWS, 2010.

[b] As of November 30, 2010, 102 avian species had been identified through the *Deepwater Horizon* post-spill monitoring and collection process. Overall oiling rate across species including "others" and "unknowns" was 0.27. Oiling rate for the Top 5 (see bold rows in table) most-impacted avian species was 0.44 and included representatives from *only* the seabird group. In descending order based on the number collected: laughing gull (3,339 collected, 0.39 oiling rate); brown pelican (911 collected, 0.38 oiling rate); northern gannet (632 collected, 0.65 oiling rate); royal tern (348 collected, 0.52 oiling rate); and black skimmer (263 collected, 0.25 oiling rate).

[*] Species Group: As defined in the text of this Supplemental EIS.

[1] Oiling Rate: For each species, an oiling rate was calculated by dividing the "total" number of oiled individuals (∑ alive + dead) /∑ of individuals collected for a given species/row. In general, it has been well documented that the number of birds collected after a spill event *represents a small fraction* of the total oiled population (direct mortality) due to various factors: species-specific differences in vulnerability to spilled oil; species-specific differences in distribution, habitat use, and behavior; species-specific differences in abundance; species-specific differences in carcass deposition rates, persistence rates, and detection probabilities; overall search effort and

temporal and spatial variation in search effort; and carcass loss due to predation, habitat, weather, tides, and currents (Piatt et al., 1990a and 1990b; Ford et al., 1996; Piatt and Ford, 1996; Fowler and Flint, 1997; Flint and Fowler, 1998; Flint et al., 1999; Castege et al., 2007; Byrd et al., 2009; Flint et al., 2010). For example, Piatt and Ford (1996, Table 1) estimated a mean carcass recovery rate of only 17% for a number of previous oil-bird impact studies. Burger (1993) and Wiese and Jones (2001) estimated recovery rates of 20%, with the latter study based on a drift-block design to estimate carcass recovery rate from beached-bird surveys. NOTE: Spill volume tends to be a poor predictor of bird mortality associated with an oil spill (Burger 1993), although it should be considered for inclusion in any models to estimate total bird mortality, preferably with some metric of species composition and abundance (preferably density) pre-spill (Wilhelm et al., 2007).

[2] For additional information on oiling rates by Species Group and additional statistics, see Table 4-5.

Table 4-7

Mississippi Department of Marine Resources: Summary of Fish Kills Observed along the Gulf Coast

Date	Area	Dissolved Oxygen	Fish
May 5, 2010	Bayou Chicot, LA	<1.0 mg/l	3.3 million juvenile menhaden*
May 5, 2010	Lake Mars Boat Ramp, Belle Fontaine, MS	2 mg/l	1.9 million menhaden*
May 11-12, 2010	Mississippi beaches	5-5.7 mg/l	27 hardhead catfish
July 8, 2010	Bayou Caddy, MS	1.7 mg/l	97 with 11 species†
August 1, 2010	Long Beach Harbor, MS	NA	1,900 with 23 species‡
August 3, 2010	Mississippi Sound south of Deer Island	NA	500,000 menhaden* (broken net)
August 5, 2010	Pass Christian Harbor, MS	6.7 mg/l	NA

* Abundance of menhaden are estimates from the kill site.
† Species include trout, croaker, sheepshead, mullet, flounder, drum, catfish, and pinfish.
‡ Species include brown shrimp, crabs, stingrays, kingfish, silver perch, shrimp, eel, lookdown, least puffer, lizardfish, cusk-eel, black cheek, tonguefish, bay whiff, and Atlantic spadefish.
NA = not available.
Source: Devers, written communication, 2010.

Table 4-8

Economic Significance of Commercial Fishing in the Gulf of Mexico

State	Landings Revenue	Sales Impacts	Job Impacts	CFQ
Alabama	44,317	445,449	9,750	0.33
Florida	169,711	5,657,246	108,695	0.99
Louisiana	272,884	2,033,587	43,711	2.50
Mississippi	43,696	390,702	8,575	1.96
Texas	176,098	2,013,272	42,541	0.32
Total	706,706	10,540,256	213,272	--

Source: USDOC, NOAA, 2010c.

Table 4-9

Top Species Caught by Recreational Fishers in the Gulf Coast States

Number of Fish									
Species/Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Atlantic Croaker	4,186,990	3,589,525	3,488,464	4,342,264	2,659,716	3,905,810	3,979,556	4,245,495	5,331,132
Black Drum	1,509,119	1,586,284	1,523,614	1,686,081	1,115,153	1,346,737	1,233,862	1,728,173	1,672,719
Blackfin Tuna	50,581	35,051	38,601	73,301	60,501	64,825	83,375	92,763	91,581
Cobia	175,045	163,606	127,512	125,923	108,746	108,656	117,448	161,636	88,721
Dolphins	555,466	364,917	609,001	434,879	316,110	315,264	430,367	368,457	251,429
Gag	2,386,672	2,996,920	3,878,651	4,197,440	2,938,891	2,084,588	3,254,196	4,746,177	2,924,329
Gray Snapper	3,511,496	3,798,482	6,073,935	4,530,800	5,851,190	4,039,090	5,571,680	7,669,142	4,401,510
Great Amberjack	477,424	315,674	346,070	254,283	201,443	161,534	199,429	245,344	207,226
King Mackerel	575,699	488,142	398,234	447,247	380,793	967,378	429,562	376,508	596,232
Little Tuny	265,456	423,424	197,927	362,243	153,204	293,337	333,310	193,546	179,928
Pinfishes	14,675,911	11,664,212	8,848,476	13,813,893	10,274,164	10,324,881	11,762,014	15,942,884	11,591,996
Red Drum	8,261,019	7,351,899	8,587,461	8,387,639	7,492,498	9,838,039	9,030,204	9,700,431	8,063,967
Red Grouper	1,880,567	2,197,298	2,298,287	3,632,743	1,862,289	1,012,572	1,198,064	3,312,054	3,410,731
Red Snapper	2,654,554	3,196,853	2,934,322	3,217,643	2,732,425	3,527,145	3,872,259	2,624,982	2,910,337
Sand Seatrout	4,342,805	4,129,064	4,062,981	3,326,749	2,524,347	4,334,134	4,587,006	5,853,369	6,502,913
Sheepshead	3,126,988	3,253,252	3,945,716	4,669,176	3,961,753	2,992,718	2,397,513	3,229,301	3,189,143
Southern Flounder	902,531	622,566	911,039	917,938	692,293	738,351	802,929	691,132	757,326
Southern Kingfish	2,660,631	1,404,170	1,733,446	2,206,406	1,988,897	1,848,665	1,608,861	1,727,889	1,670,001
Spanish Mackerel	4,321,962	3,882,193	3,715,281	4,303,273	2,518,250	4,946,966	3,817,443	4,132,207	2,988,112
Spotted Seatrout	20,582,815	22,664,920	28,785,103	28,851,638	29,679,185	36,435,823	30,611,531	32,564,976	29,352,993
Striped Mullet	2,293,741	1,340,382	1,866,563	1,257,205	1,323,021	1,303,076	1,162,019	1,231,121	969,123
White Grunt	6,779,775	5,529,179	4,831,100	5,133,524	3,687,435	1,694,738	2,157,816	4,036,236	2,490,431
Pounds									
Species/Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Atlantic Croaker	677,890	287,934	490,887	306,179	280,489	553,449	600,690	598,106	508,967
Black Drum	2,341,032	2,531,258	2,857,730	3,057,965	1,922,411	2,531,999	2,276,953	2,907,574	2,870,621
Blackfin Tuna	526,547	294,526	580,484	830,021	525,045	863,090	286,572	868,698	660,264
Cobia	1,129,714	791,793	1,101,782	1,227,464	1,208,989	1,072,033	1,012,921	913,566	534,810
Dolphins	2,496,877	2,227,922	2,530,400	2,011,021	1,222,221	1,183,392	2,028,360	1,327,670	1,358,031
Gag	3,854,869	3,781,229	3,278,245	4,693,183	3,510,799	1,936,492	2,534,137	3,071,762	1,594,303
Gray Snapper	1,412,589	1,324,563	1,893,108	2,044,198	1,964,576	1,975,178	1,512,298	2,065,549	1,604,298
Great Amberjack	1,153,786	1,847,882	2,416,947	2,251,265	1,358,653	1,282,616	989,630	1,213,319	1,484,002
King Mackerel	2,865,226	3,043,569	2,763,371	2,434,372	1,635,507	3,374,852	2,606,005	1,894,691	3,324,003
Little Tuny	587,429	873,813	590,683	1,108,632	310,877	619,746	813,722	385,382	578,719
Pinfishes	1,560,872	1,677,357	1,739,776	3,811,171	1,215,008	742,368	1,683,034	3,510,949	2,831,692
Red Drum	13,419,400	11,575,766	13,113,186	14,290,334	10,242,490	14,215,737	13,988,083	13,910,457	11,898,383
Red Grouper	1,415,307	1,744,180	1,359,015	3,235,764	1,431,359	980,311	1,039,597	896,377	926,111
Red Snapper	3,737,264	4,369,698	3,921,340	4,162,485	3,322,074	3,232,025	3,769,388	3,128,771	3,613,267
Sand Seatrout	1,905,500	1,723,872	1,556,192	1,121,936	879,417	1,557,953	1,701,233	1,930,689	2,389,301
Sheepshead	4,385,765	3,775,195	5,002,901	6,487,492	5,288,789	4,013,009	3,836,123	4,670,992	4,388,254
Southern Flounder	1,082,858	630,928	823,083	834,794	645,835	780,468	810,986	749,674	851,999
Southern Kingfish	993,027	581,779	683,569	783,204	657,967	616,415	608,426	629,250	710,651
Spanish Mackerel	3,549,609	3,202,118	2,614,570	2,907,069	1,583,811	2,655,099	2,542,007	2,788,369	1,962,775
Spotted Seatrout	12,514,780	9,684,768	11,881,531	11,880,671	11,761,193	18,057,746	13,817,897	15,180,141	14,500,754
Striped Mullet	2,330,227	1,523,427	2,194,545	1,525,980	1,536,234	1,600,983	1,245,425	1,418,025	900,037
White Grunt	2,352,568	2,019,945	1,785,777	1,751,156	1,602,724	680,403	701,343	1,325,970	1,013,062

Note: Fish that are released alive are included in the landings data but not in the weight data.
Note: This table presents the sum of fishing data for Louisiana, Mississippi, Alabama, and West Florida.
Source: USDOC, NOAA 2010d.

Table 4-10

Percentage of Species Landings that are Ocean Based

Number of Fish									
Species/Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Atlantic Croaker	14.44	10.97	13.76	27.27	10.77	11.41	12.42	6.85	5.54
Black Drum	10.11	9.76	11.49	11.39	16.10	9.48	4.41	4.66	5.41
Blackfin Tuna	100.00	100.00	100.00	100.00	96.64	100.00	100.00	100.00	100.00
Cobia	64.14	72.50	74.56	79.25	83.60	86.83	81.25	73.28	71.72
Dolphins	98.92	100.00	100.00	100.00	100.00	99.72	99.49	99.21	100.00
Gag	82.69	75.01	76.77	81.08	83.59	71.17	63.72	71.40	61.45
Gray Snapper	49.48	32.43	41.52	42.93	36.45	49.40	40.26	48.61	32.00
Great Amberjack	96.21	99.63	99.51	99.74	99.18	98.85	100.00	99.44	100.00
King Mackerel	97.34	96.94	99.20	95.87	93.48	62.50	94.85	93.83	93.00
Little Tuny	97.84	96.08	99.76	99.80	99.10	92.75	87.64	86.66	87.22
Pinfishes	36.89	31.37	48.33	30.53	43.72	44.88	26.31	37.73	24.59
Red Drum	18.34	13.25	14.44	13.50	21.46	17.50	12.96	12.48	7.45
Red Grouper	98.33	99.38	98.22	97.36	98.12	98.60	97.14	91.04	83.08
Red Snapper	99.32	99.67	99.49	99.20	98.38	98.21	97.97	96.82	98.39
Sand Seatrout	22.81	14.26	11.90	24.40	19.24	23.00	21.26	13.97	12.28
Sheepshead	30.22	23.09	19.56	22.49	24.68	28.70	32.45	19.91	13.34
Southern Flounder	14.11	15.62	5.44	15.59	12.10	8.26	12.23	6.21	4.68
Southern Kingfish	48.30	43.11	33.38	29.19	26.33	39.34	28.73	36.84	18.05
Spanish Mackerel	69.03	53.39	68.10	73.05	63.10	67.63	55.73	70.40	51.93
Spotted Seatrout	23.52	25.12	20.03	18.99	22.97	20.61	23.59	17.20	15.36
Striped Mullet	18.47	13.28	13.20	13.04	28.14	38.07	15.12	21.97	9.98
White Grunt	79.12	86.20	85.07	87.96	91.14	90.42	78.79	85.87	69.51
Pounds									
Species/Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Atlantic Croaker	10.99	12.90	18.98	11.59	3.21	6.63	8.58	5.00	2.37
Black Drum	16.37	21.47	10.60	17.86	9.56	7.15	6.12	6.30	12.54
Blackfin Tuna	100.00	100.00	100.00	100.00	91.49	100.00	100.00	100.00	100.00
Cobia	87.14	80.65	84.22	92.18	95.30	92.92	87.02	87.07	75.04
Dolphins	99.00	100.00	100.00	100.00	100.00	100.00	100.00	99.57	100.00
Gag	97.52	96.43	95.77	96.10	93.16	94.32	89.21	90.92	81.40
Gray Snapper	75.80	75.27	74.21	80.80	84.10	75.51	70.68	71.76	59.57
Great Amberjack	100.00	100.00	99.97	100.00	99.71	100.00	100.00	100.00	100.00
King Mackerel	99.08	96.50	99.46	98.06	98.58	82.52	96.19	97.61	96.20
Little Tuny	100.00	100.00	99.58	99.98	100.00	95.96	70.54	94.12	92.99
Pinfishes	41.84	34.38	56.40	26.93	48.10	54.05	19.22	25.85	22.79
Red Drum	18.82	15.84	16.08	19.52	15.07	15.14	14.94	10.93	7.22
Red Grouper	99.30	99.73	99.71	99.86	100.00	100.00	98.89	97.43	98.25
Red Snapper	99.85	99.83	99.81	98.32	99.45	98.97	96.89	98.31	98.53
Sand Seatrout	21.90	13.65	11.51	26.39	20.30	24.21	19.14	14.25	15.06
Sheepshead	43.70	30.20	26.82	26.65	34.75	39.45	47.43	23.60	13.88
Southern Flounder	16.88	16.23	6.27	14.58	9.26	7.55	9.00	6.98	3.98
Southern Kingfish	51.32	41.90	28.09	27.11	30.90	33.24	28.64	42.04	15.56
Spanish Mackerel	70.72	63.52	70.76	76.73	69.40	67.47	61.28	68.15	56.71
Spotted Seatrout	25.10	28.31	16.25	17.92	20.36	15.85	19.12	14.32	14.31
Striped Mullet	24.07	10.45	7.14	14.07	22.48	31.63	12.10	27.41	6.60
White Grunt	89.48	90.69	91.05	89.34	93.79	94.64	83.12	90.31	83.39

Note: Fish that are released alive are included in the landings data but not in the weight data.

Note: This table presents the sum of fishing data for Louisiana, Mississippi, Alabama, and West Florida.

Note: The NMFS divides fishing data into inland, State, and Federal categories. Ocean based is defined as the sum of State and Federal categories.

Source: USDOC, NOAA 2010d.

Table 4-11

Recreational Fishing Participation 2009

State	Coastal	Noncoastal	Out of State	Total
West Florida	1,551,478	0	1,670,603	3,222,081
East Florida	1,098,575	0	1,741,339	2,839,914
Alabama	205,365	151,379	208,775	565,519
Mississippi	125,048	36,496	50,328	211,872
Louisiana	668,576	108,086	139,120	915,782

Source: USDOC, NOAA, 2010d.

State	Resident	Nonresident	Total
Florida	1,881	885	2,767
Texas	2,308	218	2,527
Alabama	600	206	806
Mississippi	465	80	546
Louisiana	590	112	702

Source: USDOI, FWS, and USDOC, Census Bureau, 2006.

Table 4-12

Angler Trips in the Gulf of Mexico during Certain Months of 2009 and 2010

	2009					2010			
	Jan/Feb	Mar/April	May/June	July/Aug		Jan/Feb	Mar/April	May/June	July/Aug
Total Trips									
Alabama	134,887	309,545	454,940	405,356		84,493	275,061	392,199	354,099
Florida	2,205,141	2,588,254	3,963,196	3,422,240		1,760,394	1,947,677	3,517,096	3,082,397
Louisiana	583,195	561,112	1,058,162	838,820		367,898	559,726	901,671	583,342
Mississippi	127,336	148,993	222,623	251,448		90,718	174,983	334,441	159,674
Total	3,050,559	3,607,904	5,698,921	4,917,864		2,303,503	2,957,447	5,145,407	4,179,512
Inland									
Alabama	90,030	201,215	271,504	225,383		90,030	55,150	147,288	237,353
Florida	1,432,011	1,579,247	2,227,167	2,077,674		1,432,011	1,445,472	1,307,968	2,101,879
Louisiana	568,870	552,088	990,311	718,606		568,870	357,404	546,930	880,636
Mississippi	121,012	145,411	201,851	241,075		121,012	90,067	171,824	326,780
Total	2,211,923	2,477,961	3,690,833	3,262,738		2,211,923	1,948,093	2,174,010	3,546,648
State									
Alabama	44,218	93,732	80,117	114,938		29,006	113,399	116,297	180,098
Florida	662,919	927,192	1,423,612	1,105,167		242,215	548,438	1,176,779	949,626
Louisiana	5,302	1,728	38,986	61,425		7,068	10,970	14,779	11,386
Mississippi	1,150	273	7,627	10,191		651	3,042	7,661	--
Total	713,589	1,022,925	1,550,342	1,291,721		278,940	675,849	1,315,516	1,141,110
Federal									
Alabama	639	14,597	103,320	65,035		336	14,374	38,548	313
Florida	110,211	81,815	312,418	239,399		72,707	91,271	238,438	170,106
Louisiana	9,023	7,296	28,865	58,788		3,427	1,826	6,256	6,986
Mississippi	5,175	3,309	13,144	182		--	--	--	--
Total	125,048	107,017	457,747	363,404		76,470	107,471	283,242	177,405

Note: This table presents the sum of fishing data for Louisiana, Mississippi, Alabama, and West Florida.
Source: USDOC, NOAA, 2010d.

Table 4-13

Angler trips in the Gulf of Mexico by Location and Mode in 2009

State	Area	Number of Trips	% State Total
Alabama	Shore Ocean (< 3 nmi)	354,043	20.6
	Shore Inland	407,982	23.8
	Charter Ocean (<3 nmi)	9228	0.5
	Charter Ocean (>3 nmi)	36672	2.1
	Charter Inland	10759	0.6
	Private/Rental Ocean (<3 nmi)	154301	9.0
	Private/Rental Ocean (>3 nmi)	165012	9.6
	Private/Rental Inland	579033	33.7
	Total	1,717,030	
West Florida	Shore Ocean (< 9 nmi)	2,511,933	16.2
	Shore Inland	3,942,920	25.4
	Charter Ocean (<9 nmi)	195,688	1.3
	Charter Ocean (>9 nmi)	259,622	1.7
	Charter Inland	112,007	0.7
	Private/Rental Ocean (<9 nmi)	2,602,581	16.8
	Private/Rental Ocean (>9 nmi)	616,371	4.0
	Private/Rental Inland	5,276,236	34.0
	Total	15,517,358	
Louisiana	Shore Ocean (< 3 nmi)	37,324	0.9
	Shore Inland	731,676	18.3
	Charter Ocean (<3 nmi)	3,283	0.1
	Charter Ocean (>3 nmi)	18,031	0.5
	Charter Inland	135,654	3.4
	Private/Rental Ocean (<3 nmi)	75,482	1.9
	Private/Rental Ocean (>3 nmi)	102,196	2.6
	Private/Rental Inland	2,896,326	72.4
	Total	3,999,972	
Mississippi	Shore Ocean (< 3 nmi)	330	0.0
	Shore Inland	307,856	29.0
	Charter Ocean (<3 nmi)	2,831	0.3
	Charter Ocean (>3 nmi)	330	0.0
	Charter Inland	7,680	0.7
	Private/Rental Ocean (<3 nmi)	18,602	1.8
	Private/Rental Ocean (>3 nmi)	26,095	2.5
	Private/Rental Inland	698,752	65.8
	Total	1,062,476	
Gulf Total	Shore Ocean (< 3 nmi)	2,903,630	13.0
	Shore Inland	5,390,434	24.2
	Charter Ocean (<3 nmi)	211,030	0.9
	Charter Ocean (>3 nmi)	314,655	1.4
	Charter Inland	266,100	1.2
	Private/Rental Ocean (<3 nmi)	2,850,966	12.8
	Private/Rental Ocean (>3 nmi)	909,674	4.1
	Private/Rental Inland	9,450,347	42.4
	Total	22,296,836	

Note: This table presents the sum of fishing data from Louisiana, Mississippi, Alabama, and West Florida
Note: State waters in Florida extend 9 nautical miles from the coast rather than the typical 3 nautical miles.
Source: USDOC, NOAA, 2010d.

Table 4-14

Economic Impact of Recreational Fishing in the Gulf of Mexico in 2008

	Expenditures*	Sales*	Value Added*	Employment
Alabama	480,587	455,093	235,481	4,719
West Florida	6,332,287	5,650,068	3,075,710	54,589
Mississippi	410,007	382,778	148,837	2,930
Louisiana	2,727,225	2,297,078	1,156,796	25,590
Texas	2,594,714	3,288,135	1,656,545	25,544
Total	12,544,820	12,073,152	6,273,369	113,372

*Data on expenditures, sales, and value added are presented in thousands of dollars.
Source: USDOC, NOAA, 2010c.

Table 4-15

Fish Species Caught by Recreational Anglers during Certain Months of 2009 and 2010

Species/Year	2009				2010			
Months	Jan/Feb	Mar/April	May/June	July/Aug	Jan/Feb	Mar/April	May/June	July/Aug
Number of Fish								
Atlantic Croaker	145,458	809,858	1,816,279	1,625,287	50,971	386,179	1,944,042	1,044,961
Black Drum	161,376	164,735	325,061	224,853	227,071	225,385	364,503	275,733
Blackfin Tuna	27,354	4,581	3,530	26,771	949	1,932	4,657	13,858
Cobia	584	4,475	40,360	34,150	871	14,029	28,830	15,197
Dolphins	12,011	14,355	130,214	84,491	2,113	19,700	136,119	26,805
Gag	395,418	296,874	811,646	478,649	230,505	220,433	634,532	366,454
Gray Snapper	485,160	635,363	934,055	1,451,321	313,131	222,635	407,943	714,142
Great Amberjack	31,396	12,326	104,533	45,653	68,638	55,138	146,875	42,207
King Mackerel	19,359	63,883	202,625	188,375	5,607	32,121	146,680	40,138
Little Tuny	19,291	9,276	32,635	38,169	3,955	8,159	15,674	51,860
Pinfishes	1,371,965	1,391,786	2,470,196	4,232,636	533,986	701,588	4,025,971	3,181,734
Red Drum	982,472	747,513	1,361,522	1,484,450	925,532	1,198,622	1,577,535	1,452,287
Red Grouper	437,521	250,878	1,198,225	691,905	62,283	147,913	771,742	397,990
Red Snapper	84,572	106,800	1,458,523	1,018,133	161,625	120,570	619,128	172,683
Sand Seatrout	269,556	638,973	2,068,415	1,612,595	111,317	630,783	1,851,837	859,674
Sheepshead	1,272,356	901,817	135,120	169,281	746,819	997,496	179,120	110,364
Southern Flounder	36,231	57,573	143,744	213,087	18,603	85,698	267,215	315,046
Southern Kingfish	76,964	289,755	500,087	405,015	133,317	149,150	500,078	131,282
Spanish Mackerel	81,393	472,775	1,059,242	612,279	12,449	592,166	691,469	1,132,884
Spotted Seatrout	3,771,209	2,719,521	8,622,412	5,350,897	1,539,569	1,719,419	5,585,438	4,486,243
Striped Mullet	198,193	31,379	109,002	322,672	31,735	8,328	260,327	413,764
White Grunt	518,784	236,420	448,748	554,624	160,520	252,943	729,231	602,460
Pounds								
Atlantic Croaker	11,715	57,628	173,870	166,893	12,044	24,010	200,460	107,664
Black Drum	272,586	352,421	531,320	546,397	298,282	660,342	306,550	386,283
Blackfin Tuna	202,746	21,076	30,382	265,762	10,708	0	73,709	79,780
Cobia	0	65,580	133,791	297,808	15,919	193,213	171,895	88,019
Dolphins	77,512	90,040	630,635	476,560	10,000	47,840	380,042	120,936
Gag	87,005	146,676	566,695	246,203	171,685	198,240	560,661	179,243
Gray Snapper	152,724	162,960	446,707	618,699	32,209	73,124	189,543	282,467
Great Amberjack	187,900	73,076	693,653	459,602	75,765	314,726	542,118	109,240
King Mackerel	111,522	214,979	983,633	1,136,665	38,517	176,646	972,566	208,339
Little Tuny	68,459	41,731	87,565	165,513	11,933	44,784	41,341	213,463
Pinfishes	258	313,523	747,119	1,375,430	747,218	206,004	347,535	513,628
Red Drum	817,402	1,345,542	2,748,252	2,309,682	1,184,906	2,269,014	2,288,800	2,079,421
Red Grouper	21,369	53,245	307,916	411,885	14,533	37,661	214,075	146,487
Red Snapper	0	0	1,683,450	1,929,816	0	0	396,817	286,040
Sand Seatrout	148,892	220,669	765,417	492,922	54,110	230,046	639,504	387,178
Sheepshead	1,685,580	1,480,944	201,108	222,947	666,634	1,464,578	197,581	60,044
Southern Flounder	29,987	59,601	147,221	233,972	13,772	105,545	282,568	332,260
Southern Kingfish	39,828	125,402	216,637	228,593	68,592	57,467	159,080	47,474
Spanish Mackerel	109,864	320,961	683,805	431,326	8,241	359,894	462,765	501,242
Spotted Seatrout	1,445,014	1,134,580	5,358,179	2,776,994	478,076	811,950	3,312,727	1,805,049
Striped Mullet	124,267	4,899	67,245	330,619	44,936	7,566	265,989	686,934
White Grunt	272,297	115,689	140,164	180,879	94,253	125,841	231,324	253,337

Note: Fish that are released alive are included in the landings data but not in the weight data.
Note: This table presents the sum of fishing data for Louisiana, Mississippi, Alabama, and West Florida.
Source: USDOC, NOAA, 2010d.

Table 4-16

Employment in the Leisure/Hospitality Industry in Selected Geographic Regions

Region	2001	2002	2003	2004	2005	2006	2007	2008	2009
Panel A—Economic Impact Area									
TX-1	45,553	46,979	48,490	49,165	50,446	53,281	54,654	54,551	53,691
TX-2	14,055	14,113	14,241	14,728	14,670	16,153	16,564	16,883	16,702
TX-3	195,214	203,090	207,245	214,025	219,203	231,840	241,110	240,231	240,366
LA-1	13,682	14,065	14,300	14,725	15,339	14,747	14,563	14,295	14,246
LA-2	17,653	17,451	18,560	19,817	20,787	21,072	21,517	21,364	20,588
LA-3	37,902	38,048	40,752	42,229	43,483	44,533	44,810	46,037	44,157
LA-4	80,990	80,677	81,243	85,093	47,641	64,812	68,531	68,605	67,438
MS-1	31,485	32,752	33,714	33,297	18,024	29,191	29,680	27,702	26,938
AL-1	23,785	23,937	24,488	24,464	25,481	26,463	26,850	26,516	26,034
FL-1	34,829	36,139	36,520	39,956	41,133	41,887	41,688	40,001	41,003
FL-2	17,934	19,733	18,860	21,588	21,861	22,478	22,913	22,502	21,699
FL-3	123,248	130,250	132,256	137,302	145,005	145,894	149,448	146,368	142,393
FL-4	238,090	251,658	256,472	268,487	274,635	280,874	283,748	283,359	280,380
TX EIA Total	254,822	264,182	269,976	277,918	284,319	301,274	312,328	311,665	310,759
LA EIA Total	150,227	150,241	154,855	161,864	127,250	145,164	149,421	150,301	146,429
MS EIA Total	31,485	32,752	33,714	33,297	18,024	29,191	29,680	27,702	26,938
AL EIA Total	23,785	23,937	24,488	24,464	25,481	26,463	26,850	26,516	26,034
FL EIA Total	414,101	437,780	444,108	467,333	482,634	491,133	497,797	492,230	485,475
EIA Total	874,420	908,892	927,141	964,876	937,708	993,225	1,016,076	1,008,414	995,635
Panel B—Coastal									
TX	57,637	59,250	60,873	61,983	63,069	67,625	68,195	67,388	68,025
LA	88,235	87,640	88,431	92,703	56,242	73,405	77,567	77,580	75,958
MS	30,052	31,295	32,172	31,625	16,152	26,926	27,444	25,575	25,080
AL	21,231	21,690	22,249	22,250	23,099	24,186	24,437	24,319	23,990
FL	377,323	399,122	404,048	423,855	437,761	445,948	450,414	445,164	441,068
Coastal Total	574,478	598,997	607,773	632,416	596,323	638,090	648,057	640,026	634,121
Panel C—Statewide									
TX	818,164	840,506	854,733	877,284	900,646	943,581	982,437	995,445	982,122
LA	191,394	192,342	198,195	206,298	171,674	189,822	194,614	194,905	189,527
MS	116,714	120,243	121,528	122,557	110,430	123,402	125,192	121,033	115,924
AL	148,989	149,172	154,287	158,390	163,390	168,558	171,697	168,413	166,237
FL	772,721	808,429	817,571	866,269	893,043	912,409	932,012	922,534	896,923
State Total	2,047,982	2,110,692	2,146,314	2,230,798	2,239,183	2,337,772	2,405,952	2,402,330	2,350,733

1) Economic Impact Areas are defined in Figure 2-2.
2) The Coastal category refers to counties within EIA's that are directly along the coast of the U.S.
3) The Statewide category refers to the number of employees within the borders of the entire state.
4) The leisure/hospitality industry is defined according to the North American Industrial Classification System (NAICS).
5) The employment figure for any given year corresponds to the total number of employees in December of that year.
Source: U.S. Dept. of Labor, Bureau of Labor Statistics, 2010.

Table 4-17

Total Wages Earned by Employees in the Leisure/Hospitality Industry in Selected Geographic Regions

Region	2001	2002	2003	2004	2005	2006	2007	2008	2009
Panel A—Economic Impact Area									
TX-1	516,185	544,244	566,896	586,252	627,083	685,028	739,142	746,670	766,750
TX-2	148,743	155,321	158,437	168,256	175,260	190,740	209,082	221,889	237,274
TX-3	3,018,006	3,184,819	3,269,332	3,482,253	3,711,467	4,067,402	4,341,536	4,559,854	4,635,997
LA-1	179,049	190,839	196,760	207,015	252,162	250,432	251,148	257,990	263,543
LA-2	176,741	186,845	195,892	219,352	243,347	280,120	295,347	308,107	314,147
LA-3	446,102	452,046	487,564	498,022	543,970	597,138	633,241	654,806	667,398
LA-4	1,318,417	1,378,771	1,429,488	1,493,019	1,409,983	1,246,477	1,505,206	1,633,224	1,595,567
MS-1	591,065	591,974	608,043	618,987	617,535	453,168	621,439	616,442	560,510
AL-1	281,331	287,381	300,006	305,922	321,934	347,512	371,712	388,644	390,968
FL-1	470,616	508,316	528,008	599,949	655,141	721,483	761,247	738,910	743,731
FL-2	182,944	209,213	210,758	232,143	249,152	270,339	294,144	293,528	291,417
FL-3	1,849,168	1,956,066	2,046,441	2,224,235	2,418,168	2,576,029	2,752,991	2,906,630	2,795,652
FL-4	4,219,638	4,391,881	4,669,982	5,131,115	5,650,225	5,981,862	6,304,312	6,493,402	6,344,752
TX EIA Total	3,682,934	3,884,384	3,994,665	4,236,761	4,513,810	4,943,170	5,289,760	5,528,413	5,640,021
LA EIA Total	2,120,309	2,208,501	2,309,704	2,417,408	2,449,462	2,374,167	2,684,942	2,854,127	2,840,655
MS EIA Total	591,065	591,974	608,043	618,987	617,535	453,168	621,439	616,442	560,510
AL EIA Total	281,331	287,381	300,006	305,922	321,934	347,512	371,712	388,644	390,968
FL EIA Total	6,722,366	7,065,476	7,455,189	8,187,442	8,972,686	9,549,713	10,112,694	10,432,470	10,175,552
EIA Total	13,398,005	14,037,716	14,667,607	15,766,520	16,875,427	17,667,730	19,080,547	19,820,096	19,607,706
Panel B—Coastal									
TX	706,679	737,035	761,880	790,346	834,820	927,109	986,605	994,817	1,027,931
LA	1,401,025	1,459,632	1,512,219	1,578,886	1,503,750	1,359,770	1,631,966	1,764,631	1,734,276
MS	579,122	579,914	595,776	605,542	602,391	433,995	600,226	594,626	539,240
AL	259,024	265,870	279,872	284,844	299,662	324,127	347,209	363,802	367,039
FL	6,309,393	6,624,756	6,991,895	7,687,112	8,410,661	8,955,648	9,456,949	9,762,721	9,522,041
Coastal Total	9,255,243	9,667,207	10,141,642	10,946,730	11,651,284	12,000,649	13,022,955	13,480,597	13,190,527
Panel C—Statewide									
TX	12,226,217	12,630,640	12,936,441	13,601,748	14,407,978	15,653,469	16,677,752	17,490,862	17,674,963
LA	2,674,740	2,762,055	2,886,189	3,028,338	3,069,485	3,013,979	3,336,193	3,530,708	3,511,171
MS	1,714,340	1,746,899	1,778,922	1,840,583	1,872,402	1,789,900	1,990,974	2,024,034	1,915,700
AL	1,682,365	1,730,048	1,800,093	1,882,015	1,998,089	2,124,157	2,244,583	2,344,058	2,345,332
FL	13,388,764	13,677,833	14,336,358	15,686,585	17,089,645	18,132,360	19,354,496	19,990,305	19,103,860
State Total	31,686,426	32,547,475	33,738,003	36,039,269	38,437,599	40,713,865	43,603,998	45,379,967	44,551,026

1) Economic Impact Areas are defined in Figure 2-2.
2) The Coastal category refers to counties within EIA's that are directly along the coast of the U.S.
3) The Statewide category refers to the number of employees within the borders of the entire state.
4) The leisure/hospitality industry is defined according to the North American Industrial Classification System (NAICS)
5) Wages are presented in thousands of dollars.
Source: U.S. Dept. of Labor, Bureau of Labor Statistics, 2010.

Table 4-18

Total Tourism Spending in Gulf Coast States
(millions of dollars)

State	2000	2001	2002	2003	2004	2005	2006	2007	2008
Texas	36,753	35,106	34,238	34,589	37,065	40,790	44,707	44,428	50,874
Louisiana	9,227	9,266	9,262	9,418	9,964	8,248	6,718	9,021	9,642
Mississippi	5,282	5,227	5,345	5,489	5,755	5,939	5,633	6,060	6,329
Alabama	5,487	5,423	5,368	5,627	6,051	6,639	6,998	7,405	7,723
Florida	60,296	56,166	54,544	56,265	61,118	64,544	66,165	68,820	70,521

Source: U.S. Travel Association, 2010.

Table 4-19

Coastal Travel, Tourism, and Recreation Estimates in 2004

State	Employees	Payroll	Establishments
Texas	13,712	$366,374	1,626
Louisiana	4,362	$158,357	544
Mississippi	12,188	$192,864	148
Alabama	1,078	$35,407	212
Florida	31,166	$721,440	2,398
Gulf Total	62,506	$949,711	4,928

Source: Kaplan and Whitman, unpublished.

Table 4-20

Number of Beaches and Beach Participation in Gulf States

State	Number of Beaches[1]	Beach Visitation[2, 3]
Texas	168	4,929,000
Louisiana	28	578,000
Mississippi	20	956,000
Alabama	25	1,527,000
Florida	634	21,989,000

[1] USEPA, 2008.
[2] U.S. Dept of Agriculture, Forest Service, 2010.
[3] Beach visitation only refers to visitors originating from within the U.S.

Table 4-21

Shipwrecks in the Gulf of Mexico Central Planning Area

Map Area	No. of Reported Wrecks	Historic Wrecks (verified)
Bay Marchand	3	1
Breton Sound	11	0
Chandeleur	8	0
East Cameron	49	1
Eugene Island	98	1
Ewing Bank	5	1
Green Canyon	15	2
Grand Isle	33	3
Lund	11	0
Mississippi Canyon	49	11
Mobile	56	2
Main Pass	65	0
South Pelto	16	0
Sabine Pass (LA)	15	0
South Marsh Island	33	1
South Pass	36	1
Ship Shoal	95	3
South Timbalier	90	2
Viosca Knoll	23	4
Vermilion	62	0
West Cameron	121	1
West Delta	62	0
Walker Ridge	3	0
TOTAL	959	34

Table 4-22

OCS and Non-OCS Program Spill Rates

OCS Program Spill Rates	
<1,000 bbl	
≤1 bbl	3,357 spills/BBO handled
≥1 and <50 bbl	91 spills/BBO handled
≥50 bbl and <1,000 bbl	7 spills/BBO handled
≥1,000 bbl	
Facility	0.13 spills/BBO handled
Pipeline	1.38 spills/BBO handled
Shuttle Tanker	0.72 spills/BBO handled
At sea	0.29 spills/BBO handled
In port	0.0.43 spills/BBO handled
Barge	1.23 spills/BBO handled
Non-OCS Program Spill Rates	
≤1,000 bbl	rate based on yearly occurrence information
≥1,000 bbl	
Tanker Worldwide	0.82 spills/BBO handled
At sea	0.46 spills/BBO handled
In port	0.36 spills/BBO handled
Tanker in U.S. waters	0.72 spills/BBO handled
At sea	0.29 spills/BBO handled
In port	0.43 spills/BBO handled
Barge in U.S. coastal, offshore and inland waters	1.23 spills/BBO handled
Pipeline	rate based on yearly occurrence information

BBO = billion barrels of oil.

Source: Anderson and LaBelle, 2000 (page 312 [Table 6], page 313 [Table 7], page 314 [Table 8], page 316 [Table 10], page 319 [Table 13]).

Table 4-23

Classification of the Gulf Economic Impact Areas

State	Area	Labor Market	County/Parish	State	Area	Labor Market	County	State	Area	Labor Market	County
Alabama	AL-1	Mobile	Baldwin	**Texas**	TX-1	Brownsville	Cameron	**Florida**	FL-1	Panama City	Bay
			Clarke				Hidalgo				Franklin
			Conecuh				Starr				Gulf
			Escambia				Willacy			Pensacola	Escambia
			Mobile			Corpus Christi	Aransas				Okaloosa
			Monroe				Brooks				Santa Rosa
			Washington				Duval				Walton
			Wilcox				Jim Wells		FL-2	Tallahassee	Calhoun
							Kenedy				Gadsden
Mississippi	MS-1	Biloxi-Gulfport	George				Kleberg				Holmes
			Greene				Nueces				Jackson
			Hancock				Refugio				Jefferson
			Harrison				San Patricio				Leon
			Jackson		TX-2	Brazoria	Brazoria				Liberty
			Pearl River				Matagorda				Wakulla
			Stone				Wharton				Washington
						Victoria	Calhoun			Lake City	Columbia
Louisiana	LA-1	Lake Charles	Allen				Colorado				Hamilton
			Beauregard				Dewitt				Lafayette
			Calcasieu				Fayette				Madison
			Cameron				Goliad				Suwannee
			Jefferson Davis				Gonzales				Taylor
			Vernon				Jackson				
							Lavaca				
							Victoria				

Table 4-23. Classification of the Gulf Economic Impact Areas (continued).

State	Area	Labor Market	County	State	Area	Labor Market	County	State	Area	Labor Market	County
									FL-3	Ocala	Citrus
	LA-2	Lafayette	Acadia								Marion
			Evangeline							Gainesville	Alachua
			Iberia		TX-3	Beaumont -	Hardin				Bradford
			Lafayette			Port Arthur	Jasper				Dixie
			St. Landry				Jefferson				Gilchrist
			St. Martin				Newton				Levy
			Vermillion				Orange				Union
										Tampa-St.	
	LA-3	Baton Rouge	Ascension				Polk			Petersburg	Hernando
			East Baton Rouge				Tyler				Hillsborough
			Iberville			Houston -	Austin				Pasco
			Livingston			Galveston	Chambers				Pinellas
			Tangipahoa				Fort Band		FL-4	Ft. Myers	Collier
			West Baton Rouge				Galveston				Lee
		Houma	Assumption				Harris			Miami	Broward
			Lafourche				Liberty				Miami-Dade
			St. Mary				Montgomery				Monroe
			Terrebonne				San Jacinto			Sarasota	Charlotte
	LA-4	New Orleans	Jefferson				Waller				DeSoto
			Orleans				Washington				Manatee
			Plaquemines								Sarasota
			St. Bernard								
			St. Charles								
			St. James								
			St. John the Baptist								
			St. Tammany								
			Washington								

Table 4-24

Demographic and Employment Baseline Projections for Economic Impact Area TX-1

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	1,625.42	1,771.25	1,807.15	1,843.24	1,879.50	1,915.95	1,952.51	2,137.01	2,323.71	2,511.01	2,886.77
Age Under 19 Years	36.1%	36.4%	36.4%	36.4%	36.4%	36.4%	36.4%	36.6%	35.7%	34.9%	33.6%
Age 20 to 34	21.0%	20.2%	20.0%	20.0%	19.9%	19.9%	19.8%	18.8%	19.2%	19.6%	20.1%
Age 35 to 49	18.7%	18.0%	17.8%	17.6%	17.4%	17.3%	17.1%	17.1%	16.5%	16.3%	15.9%
Age 50 to 64	13.5%	14.6%	14.8%	14.8%	14.9%	14.9%	14.8%	14.5%	14.3%	13.8%	13.6%
Age 65 and Over	10.7%	10.9%	11.0%	11.2%	11.4%	11.6%	11.9%	13.1%	14.3%	15.4%	16.8%
Median Age of Population (years)	33	34	34	34	35	35	35	36	36	37	38
White Population (in thousands)	18.7%	16.8%	16.4%	16.1%	15.8%	15.5%	15.3%	14.1%	13.1%	12.3%	11.2%
Black Population (in thousands)	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.0%
Native American Population (in thousands)	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
Asian and Pacific Islander Population (in thousands)	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
Hispanic or Latino Population (in thousands)	79.0%	80.9%	81.2%	81.5%	81.9%	82.1%	82.4%	83.7%	84.7%	85.5%	86.8%
Male Population (in thousands)	48.7%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%
Total Employment (in thousands of jobs)	728.91	840.00	864.86	878.23	891.81	905.55	919.48	991.85	1,069.01	1,151.17	1,331.45
Farm Employment	1.7%	1.6%	1.6%	1.5%	1.5%	1.5%	1.4%	1.3%	1.2%	1.1%	0.9%
Forestry, Fishing, Related Activities	1.2%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%	0.8%	0.7%
Mining	1.8%	2.4%	2.4%	2.3%	2.3%	2.3%	2.3%	2.1%	2.0%	1.8%	1.6%
Utilities	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%
Construction	7.2%	6.0%	6.0%	6.0%	5.9%	5.9%	5.9%	5.8%	5.8%	5.7%	5.5%
Manufacturing	4.0%	3.2%	3.1%	3.1%	3.0%	3.0%	3.0%	2.7%	2.5%	2.3%	2.0%
Wholesale Trade	2.8%	2.4%	2.4%	2.3%	2.3%	2.3%	2.3%	2.1%	2.0%	1.9%	1.7%
Retail Trade	12.0%	11.4%	11.4%	11.3%	11.3%	11.3%	11.2%	11.1%	10.9%	10.7%	10.3%
Transportation and Warehousing	3.3%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%
Information Employment	1.2%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%
Finance and Insurance	3.1%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
Real Estate / Rental and Lease	3.0%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	3.0%	3.0%	3.0%
Professional and Technical Services	3.4%	3.2%	3.2%	3.2%	3.2%	3.3%	3.3%	3.4%	3.5%	3.7%	3.9%
Management	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%
Administrative and Waste Services	5.4%	5.6%	5.7%	5.7%	5.8%	5.8%	5.9%	6.1%	6.3%	6.6%	7.0%
Educational Services	0.8%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%
Health Care and Social Assistance	15.6%	17.9%	18.0%	18.2%	18.4%	18.6%	18.7%	19.6%	20.5%	21.4%	23.3%
Arts, Entertainment, and Recreation	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%
Accommodation and Food Services	7.2%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%	7.2%	7.2%
Other Services, Except Public Administration	6.5%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.4%	6.4%	6.4%
Federal Civilian Government	1.7%	1.8%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.5%	1.4%	1.2%
Federal Military	1.3%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	0.9%	0.9%	0.8%	0.7%
State and Local Government	15.1%	15.7%	15.6%	15.6%	15.6%	15.5%	15.5%	15.3%	15.1%	14.9%	14.4%

Table 4-24. Demographic and Employment Baseline Projections for Economic Impact Area TX-1 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	24,168.27	25,503.71	26,303.90	26,962.27	27,636.74	28,327.69	29,035.50	32,841.93	37,134.15	41,972.31	53,564.65
Farm	1.6%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.3%	0.3%	0.2%
Forestry, Fishing, Related Activities	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.4%
Mining	3.6%	5.4%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
Utilities	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Construction	7.5%	6.2%	6.6%	6.5%	6.4%	6.3%	6.3%	5.9%	5.5%	5.1%	4.4%
Manufacturing	5.9%	4.8%	4.9%	4.8%	4.8%	4.7%	4.6%	4.3%	4.0%	3.6%	3.1%
Wholesale Trade	4.2%	4.0%	4.1%	4.1%	4.0%	4.0%	4.0%	3.8%	3.6%	3.4%	3.1%
Retail Trade	8.8%	7.9%	8.0%	7.9%	7.9%	7.9%	7.8%	7.6%	7.4%	7.1%	6.7%
Transportation and Warehousing	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.5%	3.4%	3.4%	3.3%
Information	1.5%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
Finance and Insurance	3.4%	2.9%	2.9%	2.9%	2.9%	3.0%	3.0%	3.1%	3.2%	3.3%	3.5%
Real Estate / Rental and Lease	1.4%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.3%
Professional and Technical Services	4.6%	3.9%	3.8%	3.8%	3.9%	3.9%	3.9%	4.1%	4.2%	4.3%	4.6%
Management	0.1%	0.3%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.4%	0.4%
Administrative and Waste Services	3.0%	3.2%	3.2%	3.3%	3.3%	3.3%	3.4%	3.5%	3.7%	3.9%	4.3%
Educational Services	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%
Health Care and Social Assistance	14.9%	17.9%	18.0%	18.2%	18.4%	18.6%	18.8%	19.8%	20.8%	21.8%	23.8%
Arts, Entertainment, and Recreation	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%
Accommodation and Food Services	3.4%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.1%	3.1%	3.1%	3.0%
Other Services, Except Public Administration	4.5%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%
Federal Civilian Government	4.9%	5.6%	5.5%	5.5%	5.4%	5.4%	5.4%	5.2%	5.1%	4.9%	4.6%
Federal Military	2.8%	2.8%	2.8%	2.7%	2.7%	2.7%	2.6%	2.5%	2.4%	2.3%	2.0%
State and Local Government	17.8%	18.8%	18.7%	18.7%	18.7%	18.7%	18.8%	18.8%	18.9%	18.9%	18.8%
Total Personal Income Per Capita (in 2005 dollars)	21,146	22,321	22,304	22,511	22,729	22,955	23,191	24,519	26,103	27,956	32,387
Woods & Poole Economics Wealth Index (U.S. = 100)	68.3	75.0	74.8	74.9	75.0	75.2	75.3	75.9	76.5	77.0	77.8
Persons Per Household (in number of people)	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.1	3.1	3.2
Mean Household Total Personal Income (in 2005 dollars)	69,895	79,290	79,758	80,471	81,303	82,071	82,820	87,661	93,266	100,012	116,180
Number of Households (in thousands)	499.93	548.88	560.61	573.81	586.98	600.13	613.23	677.74	740.82	801.64	914.78
Income < $10,000 (thousands of households, 2000 dollars)	15.6%	14.2%	13.9%	13.7%	13.5%	13.3%	13.1%	12.0%	10.6%	9.0%	6.7%
Income $10,000 to $19,999	17.6%	16.0%	15.7%	15.5%	15.2%	15.0%	14.8%	13.6%	12.0%	10.2%	7.6%
Income $20,000 to $29,999	15.0%	13.8%	13.6%	13.4%	13.2%	13.0%	12.8%	11.7%	10.3%	8.8%	6.5%
Income $30,000 to $44,999	18.8%	19.9%	20.0%	20.1%	20.2%	20.3%	20.4%	20.5%	19.8%	17.5%	13.0%
Income $45,000 to $59,999	12.5%	13.7%	14.0%	14.2%	14.4%	14.6%	14.8%	16.0%	17.7%	19.7%	19.7%
Income $60,000 to $74,999	7.7%	8.5%	8.6%	8.7%	8.9%	9.0%	9.1%	9.9%	11.2%	13.1%	17.3%
Income $75,000 to $99,999	6.6%	7.2%	7.3%	7.4%	7.5%	7.7%	7.8%	8.4%	9.5%	11.1%	15.0%
Income $100,000 or more	6.1%	6.7%	6.8%	6.9%	7.1%	7.2%	7.3%	7.9%	8.9%	10.5%	14.2%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 13 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-25

Demographic and Employment Baseline Projections for Economic Impact Area TX-2

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	579.99	626.33	634.39	642.51	650.70	658.94	667.23	709.17	751.75	794.43	879.89
Age Under 19 Years	29.7%	29.4%	29.3%	29.3%	29.2%	29.2%	29.1%	29.1%	28.9%	28.5%	27.9%
Age 20 to 34	18.6%	18.9%	19.2%	19.3%	19.4%	19.3%	19.2%	19.1%	19.0%	19.0%	19.4%
Age 35 to 49	22.5%	20.5%	20.0%	19.5%	19.1%	18.9%	18.7%	18.1%	17.9%	18.0%	18.1%
Age 50 to 64	16.8%	18.5%	18.8%	18.9%	19.1%	19.2%	19.2%	18.4%	17.2%	16.0%	15.4%
Age 65 and Over	12.3%	12.6%	12.7%	13.0%	13.2%	13.5%	13.7%	15.3%	17.1%	18.5%	19.2%
Median Age of Population (in years)	39	40	40	39	39	39	39	39	39	39	39
White Population (in thousands)	58.9%	55.1%	54.5%	53.8%	53.2%	52.6%	51.9%	48.8%	45.6%	42.5%	36.5%
Black Population (in thousands)	9.1%	9.9%	10.0%	10.0%	10.1%	10.2%	10.3%	10.7%	11.2%	11.8%	12.9%
Native American Population (in thousands)	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%
Asian and Pacific Islander Population (in thousands)	2.3%	3.1%	3.2%	3.2%	3.3%	3.3%	3.4%	3.5%	3.7%	3.8%	3.9%
Hispanic or Latino Population (in thousands)	29.4%	31.5%	32.0%	32.6%	33.1%	33.6%	34.1%	36.6%	39.1%	41.6%	46.2%
Male Population (in thousands)	50.4%	50.4%	50.4%	50.4%	50.4%	50.4%	50.4%	50.4%	50.4%	50.3%	50.2%
Total Employment (in thousands of jobs)	287.61	309.97	317.96	321.85	325.78	329.76	333.78	354.48	376.26	399.12	448.26
Farm Employment	7.4%	7.0%	6.9%	6.8%	6.7%	6.7%	6.6%	6.2%	5.8%	5.5%	4.8%
Forestry, Fishing, Related Activities	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%
Mining	2.4%	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%	3.2%	3.0%	2.9%	2.7%
Utilities	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%
Construction	9.6%	7.5%	7.5%	7.6%	7.6%	7.7%	7.8%	8.0%	8.3%	8.5%	9.0%
Manufacturing	9.7%	9.2%	9.1%	9.0%	8.9%	8.8%	8.7%	8.2%	7.8%	7.3%	6.5%
Wholesale Trade	2.7%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.4%
Retail Trade	11.3%	11.0%	11.0%	11.0%	11.0%	11.0%	11.0%	10.9%	10.9%	10.8%	10.7%
Transportation and Warehousing	2.9%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.1%	3.1%	3.1%	3.2%
Information Employment	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%
Finance and Insurance	3.4%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.8%
Real Estate / Rental and Lease	3.4%	3.6%	3.6%	3.6%	3.6%	3.6%	3.7%	3.7%	3.8%	3.9%	4.1%
Professional and Technical Services	3.9%	4.1%	4.1%	4.1%	4.2%	4.2%	4.2%	4.4%	4.6%	4.8%	5.1%
Federal Civilian Government	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%
Federal Military	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.3%
State and Local Government	12.9%	13.4%	13.4%	13.4%	13.4%	13.3%	13.3%	13.3%	13.2%	13.1%	12.8%
Management	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Administrative and Waste Services	4.6%	4.3%	4.3%	4.4%	4.4%	4.5%	4.5%	4.7%	5.0%	5.2%	5.7%
Educational Services	0.9%	1.3%	1.3%	1.3%	1.4%	1.4%	1.4%	1.5%	1.6%	1.7%	2.0%
Health Care and Social Assistance	7.7%	8.9%	8.9%	9.0%	9.1%	9.1%	9.2%	9.6%	10.0%	10.4%	11.3%
Arts, Entertainment, and Recreation	1.2%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%
Accommodation and Food Services	5.6%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.6%	5.5%	5.5%	5.3%
Other Services, Except Public Administration	6.5%	6.2%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%	6.3%

Table 4-25. Demographic and Employment Baseline Projections for Economic Impact Area TX-2 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	10,282.28	10,218.80	10,728.94	10,949.05	11,173.46	11,402.24	11,635.47	12,871.31	14,231.04	15,725.90	19,170.07
Farm Employment	3.5%	1.4%	1.2%	1.2%	1.2%	1.2%	1.1%	1.0%	0.9%	0.8%	0.7%
Forestry, Fishing, Related Activities	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%
Mining	4.3%	6.0%	5.8%	5.8%	5.8%	5.9%	5.9%	6.1%	6.3%	6.4%	6.8%
Utilities	1.6%	1.5%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.6%	1.7%	1.8%
Construction	11.7%	9.1%	10.1%	10.1%	10.0%	10.0%	10.0%	9.8%	9.6%	9.5%	9.0%
Manufacturing	20.2%	19.4%	19.6%	19.4%	19.1%	18.9%	18.7%	17.7%	16.8%	15.8%	14.0%
Wholesale Trade	3.5%	3.8%	3.7%	3.7%	3.7%	3.7%	3.7%	3.8%	3.8%	3.8%	3.9%
Retail Trade	8.1%	7.8%	7.7%	7.7%	7.7%	7.7%	7.7%	7.6%	7.5%	7.4%	7.2%
Transportation and Warehousing	3.5%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.8%	3.8%
Information Employment	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%	0.7%	0.6%
Finance and Insurance	3.0%	3.2%	3.3%	3.3%	3.4%	3.4%	3.4%	3.5%	3.6%	3.7%	3.8%
Real Estate / Rental and Lease	1.5%	1.7%	1.6%	1.6%	1.7%	1.7%	1.7%	1.8%	1.8%	1.9%	2.1%
Professional and Technical Services	3.9%	4.1%	4.1%	4.1%	4.2%	4.2%	4.3%	4.5%	4.7%	5.0%	5.5%
Management	0.1%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%
Administrative and Waste Services	2.5%	2.6%	2.6%	2.6%	2.7%	2.7%	2.7%	2.9%	3.1%	3.3%	3.7%
Educational Services	0.5%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%	0.9%	1.0%
Health Care and Social Assistance	7.5%	8.5%	8.6%	8.7%	8.7%	8.8%	8.9%	9.2%	9.6%	10.0%	10.8%
Arts, Entertainment, and Recreation	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Accommodation and Food Services	2.2%	2.5%	2.4%	2.4%	2.4%	2.4%	2.4%	2.3%	2.3%	2.2%	2.2%
Other Services, Except Public Administration	5.2%	4.9%	4.7%	4.7%	4.7%	4.7%	4.8%	4.8%	4.8%	4.8%	4.7%
Federal Civilian Government	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Federal Military	0.6%	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%
State and Local Government	13.9%	15.5%	15.1%	15.1%	15.2%	15.2%	15.2%	15.4%	15.5%	15.5%	15.6%
Total Personal Income Per Capita (in 2005 dollars)	29,643	30,101	30,571	30,892	31,211	31,533	31,862	33,626	35,635	37,920	43,270
Woods & Poole Economics Wealth Index (U.S. = 100)	79.0	80.7	81.0	81.2	81.4	81.6	81.8	82.8	83.8	84.8	86.9
Persons Per Household (in number of people)	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.8
Mean Household Total Personal Income (in 2005 dollars)	71,979	73,706	75,027	75,915	76,840	77,800	78,796	84,429	91,140	99,046	118,671
Total Number of Households (in thousands)	208.95	226.47	229.54	233.19	236.81	240.39	243.95	261.04	277.09	291.82	317.15
Income < $10,000 (thousands of households, 2000 dollars)	9.6%	8.8%	8.5%	8.4%	8.2%	8.1%	7.9%	7.1%	6.3%	5.5%	4.2%
Income $10,000 to $19,999	12.9%	11.8%	11.6%	11.4%	11.2%	11.0%	10.7%	9.7%	8.7%	7.6%	5.8%
Income $20,000 to $29,999	12.9%	11.9%	11.7%	11.5%	11.3%	11.1%	10.9%	9.8%	8.9%	7.8%	6.0%
Income $30,000 to $44,999	17.5%	16.9%	16.7%	16.5%	16.3%	16.1%	15.9%	14.5%	13.1%	11.5%	8.8%
Income $45,000 to $59,999	14.4%	15.0%	15.2%	15.3%	15.4%	15.6%	15.7%	16.1%	15.7%	14.2%	10.8%
Income $60,000 to $74,999	11.3%	12.1%	12.4%	12.6%	12.8%	13.0%	13.3%	14.6%	16.1%	17.6%	17.2%
Income $75,000 to $99,999	11.0%	11.9%	12.2%	12.4%	12.6%	12.8%	13.0%	14.4%	15.9%	18.1%	24.0%
Income $100,000 or More	10.6%	11.5%	11.8%	12.0%	12.2%	12.4%	12.6%	13.9%	15.4%	17.5%	23.3%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 12 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-26

Demographic and Employment Baseline Projections for Economic Impact Area TX-3

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	5,552.60	6,192.43	6,299.99	6,408.25	6,517.13	6,626.68	6,736.63	7,292.42	7,855.87	8,421.37	9,556.30
Age Under 19 years	30.9%	30.8%	30.7%	30.6%	30.6%	30.5%	30.4%	30.2%	29.7%	29.4%	28.8%
Age 20 to 34	22.3%	21.8%	21.8%	21.7%	21.7%	21.6%	21.5%	21.2%	21.4%	21.2%	20.9%
Age 35 to 49	22.7%	21.2%	20.9%	20.6%	20.4%	20.3%	20.2%	19.7%	19.1%	18.9%	19.0%
Age 50 to 64	15.6%	17.1%	17.4%	17.4%	17.5%	17.5%	17.5%	16.9%	16.1%	15.6%	15.1%
Age 65 and over	8.6%	9.1%	9.3%	9.5%	9.8%	10.1%	10.4%	12.0%	13.7%	14.9%	16.2%
Median Age of Population (in years)	37	38	38	38	38	38	38	38	39	39	40
White Population (in thousands)	46.5%	43.0%	42.3%	41.7%	41.1%	40.4%	39.8%	36.8%	33.9%	31.3%	26.4%
Black Population (in thousands)	17.4%	17.4%	17.3%	17.2%	17.0%	16.9%	16.8%	16.3%	15.7%	15.1%	13.9%
Native American Population (in thousands)	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Asian and Pacific Islander Population (in thousands)	5.4%	5.9%	6.1%	6.2%	6.3%	6.4%	6.5%	7.1%	7.6%	8.2%	9.2%
Hispanic or Latino Population (in thousands)	30.4%	33.4%	34.0%	34.6%	35.2%	35.9%	36.5%	39.5%	42.4%	45.1%	50.0%
Male Population (in thousands)	50.0%	50.1%	50.1%	50.1%	50.0%	50.0%	50.0%	49.9%	49.8%	49.7%	49.5%
Total Employment (in thousands of jobs)	3,218.66	3,596.00	3,700.61	3,758.99	3,818.15	3,878.09	3,938.83	4,254.86	4,592.14	4,951.73	5,742.46
Farm Employment	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.4%	0.4%
Forestry, Fishing, Related Activities	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Mining	2.8%	3.5%	3.4%	3.4%	3.4%	3.3%	3.3%	3.1%	2.9%	2.8%	2.5%
Utilities	0.5%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%
Construction	8.0%	7.2%	7.3%	7.3%	7.3%	7.3%	7.4%	7.5%	7.6%	7.8%	8.0%
Manufacturing	7.4%	7.4%	7.3%	7.2%	7.2%	7.1%	7.0%	6.6%	6.2%	5.9%	5.2%
Wholesale Trade	4.5%	4.3%	4.3%	4.3%	4.3%	4.2%	4.2%	4.2%	4.2%	4.2%	4.1%
Retail Trade	10.2%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.3%	9.3%	9.2%	9.0%
Transportation and Warehousing	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%	4.2%	4.2%	4.1%	4.0%
Information Employment	1.5%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.0%
Finance and Insurance	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.4%	4.4%
Real Estate / Rental and Lease	4.1%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
Professional and Technical Services	7.8%	8.0%	8.0%	8.0%	8.1%	8.1%	8.2%	8.5%	8.7%	9.0%	9.6%
Management	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%	0.8%
Administrative and Waste Services	7.4%	7.1%	7.1%	7.2%	7.2%	7.3%	7.3%	7.6%	7.9%	8.2%	8.8%
Educational Services	1.6%	1.7%	1.7%	1.8%	1.8%	1.8%	1.8%	1.8%	1.9%	1.9%	2.0%
Health Care and Social Assistance	8.2%	9.5%	9.5%	9.6%	9.6%	9.6%	9.7%	9.9%	10.1%	10.3%	10.8%
Arts, Entertainment, and Recreation	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Accommodation and Food Services	6.5%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.8%
Other Services, Except Public Administration	6.0%	5.8%	5.9%	5.9%	5.9%	5.9%	5.9%	6.0%	6.1%	6.1%	6.2%
Federal Civilian Government	1.0%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%	0.8%	0.7%	0.7%	0.6%
Federal Military	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%
State and Local Government	10.3%	10.5%	10.5%	10.4%	10.4%	10.4%	10.4%	10.3%	10.1%	10.0%	9.7%

Table 4-26. Demographic and Employment Baseline Projections for Economic Impact Area TX-3 (continued)

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	186,536.19	200,395.27	208,221.43	213,342.61	218,582.25	223,942.87	229,427.07	258,795.84	291,672.20	328,441.16	415,393.44
Farm Employment	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Forestry, Fishing, Related Activities	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Mining	12.3%	13.9%	13.7%	13.8%	13.8%	13.9%	13.9%	14.2%	14.4%	14.6%	15.0%
Utilities	1.6%	2.2%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.0%
Construction	8.2%	6.8%	7.3%	7.2%	7.2%	7.1%	7.1%	6.9%	6.6%	6.4%	5.9%
Manufacturing	11.7%	11.5%	11.8%	11.7%	11.5%	11.4%	11.3%	10.6%	10.0%	9.4%	8.4%
Wholesale Trade	6.2%	6.1%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.3%	6.3%	6.3%
Retail Trade	5.2%	4.6%	4.6%	4.6%	4.6%	4.5%	4.5%	4.4%	4.3%	4.2%	4.0%
Transportation and Warehousing	5.6%	5.6%	5.6%	5.6%	5.5%	5.5%	5.5%	5.3%	5.2%	5.1%	4.8%
Information Employment	1.7%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.2%	1.2%	1.1%
Finance and Insurance	5.5%	5.2%	5.2%	5.2%	5.2%	5.2%	5.3%	5.4%	5.4%	5.5%	5.6%
Real Estate / Rental and Lease	2.4%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.7%
Professional and Technical Services	10.8%	10.8%	10.7%	10.8%	10.8%	10.9%	11.0%	11.4%	11.8%	12.2%	13.0%
Management	0.6%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.4%	1.5%	1.6%	1.8%
Administrative and Waste Services	4.4%	3.9%	4.0%	4.0%	4.1%	4.1%	4.1%	4.3%	4.6%	4.8%	5.2%
Educational Services	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%	1.2%
Health Care and Social Assistance	6.5%	7.2%	7.1%	7.2%	7.2%	7.2%	7.3%	7.4%	7.5%	7.7%	7.9%
Arts, Entertainment, and Recreation	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%
Accommodation and Food Services	2.3%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%
Other Services, Except Public Administration	3.1%	2.9%	2.8%	2.8%	2.8%	2.8%	2.8%	2.9%	2.9%	2.9%	2.9%
Federal Civilian Government	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.6%	1.5%	1.5%	1.4%
Federal Military	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%
State and Local Government	8.3%	8.9%	8.8%	8.8%	8.8%	8.8%	8.8%	8.8%	8.8%	8.7%	8.6%
Total Personal Income Per Capita (in 2005 dollars)	38,941	38,315	39,041	39,421	39,818	40,231	40,661	43,035	45,798	48,984	56,613
Woods & Poole Economics Wealth Index (U.S. = 100)	85.7	87.4	87.9	87.8	87.6	87.5	87.4	86.9	86.7	86.7	87.2
Persons Per Household (in number of people)	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.9
Mean Household Total Personal Income (in 2005 dollars)	80,484	82,582	84,242	84,841	85,460	86,115	86,816	91,101	96,652	103,525	121,269
Total Number of Households (in thousands)	1,988.28	2,215.36	2,252.62	2,295.55	2,338.22	2,380.57	2,422.51	2,625.44	2,817.83	2,996.74	3,310.18
Income < $10,000 (thousands of households, 2000 dollars)	8.7%	8.2%	8.0%	7.9%	7.7%	7.6%	7.4%	6.7%	6.0%	5.4%	4.2%
Income $10,000 to $19,999	11.0%	10.4%	10.1%	10.0%	9.8%	9.7%	9.5%	8.6%	7.7%	6.9%	5.5%
Income $20,000 to $29,999	12.0%	11.4%	11.1%	11.0%	10.8%	10.6%	10.4%	9.4%	8.5%	7.6%	6.0%
Income $30,000 to $44,999	16.8%	16.1%	15.8%	15.6%	15.4%	15.1%	14.8%	13.5%	12.2%	11.0%	8.7%
Income $45,000 to $59,999	14.0%	14.4%	14.5%	14.5%	14.6%	14.6%	14.6%	14.2%	13.1%	11.9%	9.4%
Income $60,000 to $74,999	10.8%	11.3%	11.5%	11.7%	11.9%	12.1%	12.3%	13.4%	14.4%	14.9%	13.3%
Income $75,000 to $99,999	11.4%	12.0%	12.3%	12.4%	12.6%	12.9%	13.1%	14.4%	16.0%	17.8%	21.5%
Income $100,000 or more	15.4%	16.3%	16.7%	16.9%	17.2%	17.5%	17.9%	19.7%	22.0%	24.6%	31.3%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 17 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-27

Demographic and Employment Baseline Projections for Economic Impact Area LA1

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	334.22	334.72	336.53	338.39	340.27	342.20	344.15	354.20	364.61	375.07	396.08
Age Under 19 years	29.2%	28.5%	28.4%	28.3%	28.3%	28.2%	28.2%	28.1%	27.8%	27.2%	26.0%
Age 20 to 34	21.8%	21.9%	21.9%	21.9%	21.7%	21.4%	20.8%	19.6%	19.1%	19.0%	19.4%
Age 35 to 49	20.9%	18.9%	18.5%	18.3%	18.1%	18.1%	18.4%	18.6%	18.9%	18.2%	17.3%
Age 50 to 64	16.2%	18.1%	18.5%	18.6%	18.8%	18.9%	19.0%	18.4%	17.1%	16.9%	17.8%
Age 65 and over	11.9%	12.6%	12.6%	12.9%	13.2%	13.4%	13.6%	15.2%	17.1%	18.7%	19.6%
Median Age of Population (in years)	35	35	36	36	36	36	36	38	39	40	41
White Population (in thousands)	74.6%	73.9%	73.8%	73.8%	73.7%	73.6%	73.6%	73.2%	72.8%	72.3%	71.4%
Black Population (in thousands)	20.8%	20.7%	20.7%	20.7%	20.7%	20.7%	20.6%	20.5%	20.4%	20.4%	20.3%
Native American Population (in thousands)	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%	0.8%	0.8%
Asian and Pacific Islander Population (in thousands)	1.0%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.3%	1.4%	1.5%	1.7%
Hispanic or Latino Population (in thousands)	3.0%	3.5%	3.6%	3.7%	3.8%	3.8%	3.9%	4.3%	4.6%	5.0%	5.8%
Male Population (in thousands)	49.9%	49.8%	49.8%	49.8%	49.8%	49.8%	49.8%	49.8%	49.7%	49.7%	49.5%
Total Employment (in thousands of jobs)	171.65	177.73	182.05	183.91	185.81	187.70	189.62	199.43	209.65	220.27	242.80
Farm Employment	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.7%	1.6%	1.5%
Forestry, Fishing, Related Activities	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%
Mining	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.0%	1.0%	0.9%
Utilities	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%
Construction	8.7%	8.9%	9.0%	9.0%	9.0%	9.1%	9.1%	9.3%	9.4%	9.6%	9.8%
Manufacturing	6.7%	6.7%	6.6%	6.5%	6.4%	6.4%	6.3%	5.9%	5.5%	5.1%	4.5%
Wholesale Trade	2.2%	2.0%	2.0%	2.0%	1.9%	1.9%	1.9%	1.8%	1.7%	1.6%	1.5%
Retail Trade	11.0%	10.4%	10.4%	10.4%	10.4%	10.4%	10.4%	10.3%	10.3%	10.2%	10.0%
Transportation and Warehousing	3.2%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.7%	2.7%
Information Employment	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.9%
Finance and Insurance	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.4%	2.4%	2.3%	2.2%	2.1%
Real Estate / Rental and Lease	2.4%	2.4%	2.4%	2.4%	2.4%	2.5%	2.5%	2.5%	2.6%	2.6%	2.8%
Professional and Technical Services	4.7%	4.5%	4.5%	4.5%	4.6%	4.6%	4.7%	4.9%	5.1%	5.3%	5.8%
Management	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%
Administrative and Waste Services	3.8%	4.9%	5.0%	5.0%	5.1%	5.2%	5.3%	5.8%	6.2%	6.8%	7.9%
Educational Services	1.0%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%
Health Care and Social Assistance	9.5%	10.7%	10.8%	10.9%	11.0%	11.1%	11.2%	11.8%	12.4%	12.9%	14.1%
Arts, Entertainment, and Recreation	2.3%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.0%
Accommodation and Food Services	7.9%	7.6%	7.6%	7.6%	7.6%	7.6%	7.6%	7.7%	7.7%	7.7%	7.6%
Other Services, Except Public Administration	6.2%	5.8%	5.8%	5.8%	5.9%	5.9%	6.0%	6.2%	6.3%	6.5%	6.9%
Federal Civilian Government	2.1%	2.0%	2.0%	2.0%	2.0%	1.9%	1.9%	1.8%	1.7%	1.6%	1.4%
Federal Military	5.7%	5.8%	5.8%	5.7%	5.6%	5.6%	5.5%	5.2%	4.9%	4.6%	4.1%
State and Local Government	14.0%	14.8%	14.8%	14.7%	14.6%	14.5%	14.4%	14.0%	13.6%	13.2%	12.3%

Table 4-27. Demographic and Employment Baseline Projections for Economic Impact Area LA-1 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	6,873.26	7,285.45	7,545.69	7,677.77	7,811.98	7,948.32	8,086.83	8,813.22	9,599.12	10,449.14	12,361.78
Farm Employment	0.5%	0.8%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.4%
Forestry, Fishing, Related Activities	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Mining	1.7%	2.3%	1.9%	1.9%	1.9%	1.9%	1.9%	2.0%	2.0%	2.0%	2.1%
Utilities	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Construction	7.6%	10.9%	11.8%	11.7%	11.7%	11.6%	11.6%	11.3%	11.0%	10.7%	10.0%
Manufacturing	14.6%	12.5%	12.7%	12.6%	12.4%	12.3%	12.2%	11.5%	10.8%	10.2%	8.9%
Wholesale Trade	2.7%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.3%	2.2%	2.2%	2.0%
Retail Trade	6.3%	5.6%	5.6%	5.6%	5.5%	5.5%	5.5%	5.5%	5.4%	5.4%	5.2%
Transportation and Warehousing	3.6%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.9%	2.8%	2.8%	2.8%
Information Employment	2.6%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.3%	2.3%
Finance and Insurance	2.3%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Real Estate / Rental and Lease	1.2%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.3%	1.3%	1.4%	1.6%
Professional and Technical Services	5.4%	5.4%	5.3%	5.4%	5.5%	5.5%	5.6%	6.0%	6.3%	6.7%	7.4%
Management	1.5%	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Administrative and Waste Services	2.2%	3.0%	3.0%	3.1%	3.2%	3.2%	3.3%	3.7%	4.1%	4.5%	5.5%
Educational Services	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Health Care and Social Assistance	8.7%	9.2%	9.2%	9.3%	9.4%	9.5%	9.7%	10.2%	10.8%	11.4%	12.6%
Arts, Entertainment, and Recreation	1.5%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%
Accommodation and Food Services	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.8%
Other Services, Except Public Administration	3.7%	3.0%	3.0%	3.0%	3.1%	3.1%	3.1%	3.2%	3.3%	3.4%	3.7%
Federal Civilian Government	3.8%	4.1%	4.0%	4.0%	4.0%	4.0%	3.9%	3.9%	3.8%	3.7%	3.6%
Federal Military	10.6%	11.4%	11.3%	11.3%	11.2%	11.2%	11.2%	11.0%	10.8%	10.6%	10.1%
State and Local Government	13.8%	14.1%	13.8%	13.8%	13.8%	13.8%	13.7%	13.6%	13.4%	13.2%	12.8%
Total Personal Income Per Capita (in 2005 dollars)	27,573	29,916	30,288	30,714	31,145	31,584	32,032	34,415	37,065	39,997	46,695
Woods & Poole Economics Wealth Index (U.S. = 100)	70.1	84.8	84.6	84.8	85.0	85.2	85.4	86.4	87.4	88.4	90.3
Persons Per Household (in number of people)	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6
Mean Household Total Personal Income (in 2005 dollars)	66,070	78,879	79,669	80,570	81,502	82,473	83,478	89,133	95,837	103,681	123,003
Total Number of Households (in thousands)	123.62	124.83	125.65	126.79	127.92	129.02	130.11	135.19	139.77	143.78	150.15
Income < $10,000 (thousands of households, 2000 dollars)	12.1%	10.9%	10.6%	10.5%	10.3%	10.1%	9.9%	8.7%	7.5%	6.4%	4.8%
Income $10,000 to $19,999	14.8%	13.3%	13.0%	12.8%	12.6%	12.3%	12.1%	10.6%	9.2%	7.8%	5.8%
Income $20,000 to $29,999	13.0%	11.6%	11.3%	11.1%	10.9%	10.7%	10.5%	9.2%	7.9%	6.8%	5.0%
Income $30,000 to $44,999	19.5%	18.6%	18.4%	18.2%	17.9%	17.6%	17.4%	15.3%	13.2%	11.3%	8.3%
Income $45,000 to $59,999	15.2%	17.0%	17.4%	17.7%	18.0%	18.3%	18.6%	20.1%	20.1%	18.3%	13.8%
Income $60,000 to $74,999	9.6%	10.8%	11.1%	11.3%	11.5%	11.7%	11.9%	13.7%	16.0%	18.7%	20.4%
Income $75,000 to $99,999	8.9%	9.9%	10.2%	10.3%	10.5%	10.7%	10.9%	12.5%	14.7%	17.4%	23.7%
Income $100,000 or more	6.9%	7.8%	8.0%	8.1%	8.2%	8.4%	8.5%	9.7%	11.4%	13.4%	18.2%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 6 parishes in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-28

Demographic and Employment Baseline Projections for Economic Impact Area LA-2

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	558.39	587.88	593.59	599.38	605.23	611.14	617.10	647.47	678.54	709.79	772.62
Age Under 19 years	29.9%	28.9%	28.8%	28.7%	28.5%	28.5%	28.4%	28.2%	27.7%	27.0%	25.6%
Age 20 to 34	21.0%	22.0%	22.1%	22.0%	21.8%	21.5%	21.0%	19.5%	18.7%	18.6%	18.8%
Age 35 to 49	21.6%	19.1%	18.7%	18.4%	18.3%	18.3%	18.5%	19.3%	20.2%	19.5%	18.0%
Age 50 to 64	15.9%	18.0%	18.4%	18.6%	18.8%	18.9%	18.9%	18.4%	16.7%	16.5%	18.4%
Age 65 and over	11.6%	12.0%	12.1%	12.3%	12.6%	12.8%	13.1%	14.7%	16.7%	18.4%	19.1%
Median Age of Population (in years)	35	35	35	35	35	35	36	37	38	39	40
White Population (in thousands)	69.1%	68.3%	68.2%	68.1%	68.0%	67.9%	67.8%	67.2%	66.6%	66.0%	64.6%
Black Population (in thousands)	27.7%	28.0%	28.0%	28.0%	28.1%	28.1%	28.2%	28.4%	28.6%	28.8%	29.4%
Native American Population (in thousands)	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Asian and Pacific Islander Population (in thousands)	1.2%	1.2%	1.3%	1.3%	1.3%	1.3%	1.3%	1.5%	1.6%	1.7%	1.9%
Hispanic or Latino Population (in thousands)	1.7%	2.2%	2.2%	2.3%	2.3%	2.4%	2.4%	2.7%	2.9%	3.2%	3.8%
Male Population (in thousands)	48.6%	48.7%	48.7%	48.7%	48.8%	48.8%	48.8%	48.9%	48.9%	48.9%	48.8%
Total Employment (in thousands of jobs)	297.51	321.93	330.21	334.03	337.89	341.78	345.70	365.76	386.61	408.21	453.71
Farm Employment	1.9%	1.8%	1.8%	1.8%	1.7%	1.7%	1.7%	1.6%	1.5%	1.4%	1.3%
Forestry, Fishing, Related Activities	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Mining	6.9%	8.3%	8.3%	8.3%	8.2%	8.2%	8.2%	8.0%	7.8%	7.6%	7.2%
Utilities	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
Construction	6.7%	6.8%	6.8%	6.8%	6.7%	6.7%	6.7%	6.5%	6.3%	6.2%	5.8%
Manufacturing	6.1%	5.9%	5.8%	5.7%	5.6%	5.6%	5.5%	5.1%	4.8%	4.4%	3.8%
Wholesale Trade	3.7%	3.6%	3.6%	3.5%	3.5%	3.5%	3.5%	3.4%	3.4%	3.3%	3.2%
Retail Trade	11.5%	11.2%	11.2%	11.2%	11.1%	11.1%	11.1%	10.9%	10.7%	10.5%	10.0%
Transportation and Warehousing	3.5%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Information Employment	1.5%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
Finance and Insurance	3.4%	3.2%	3.2%	3.2%	3.2%	3.1%	3.1%	3.1%	3.0%	3.0%	2.8%
Real Estate / Rental and Lease	4.0%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%	3.2%
Professional and Technical Services	4.7%	5.2%	5.2%	5.3%	5.3%	5.3%	5.4%	5.5%	5.6%	5.8%	6.0%
Management	1.1%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%	1.0%
Administrative and Waste Services	4.6%	4.9%	4.9%	4.9%	4.9%	5.0%	5.0%	5.2%	5.3%	5.4%	5.7%
Educational Services	1.2%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Health Care and Social Assistance	11.2%	12.0%	12.1%	12.3%	12.5%	12.6%	12.8%	13.6%	14.4%	15.2%	17.0%
Arts, Entertainment, and Recreation	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%	1.6%
Accommodation and Food Services	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.5%	6.5%	6.6%	6.6%
Other Services, Except Public Administration	7.0%	7.0%	7.1%	7.1%	7.2%	7.2%	7.3%	7.6%	8.0%	8.3%	9.0%
Federal Civilian Government	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%
Federal Military	0.9%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.5%
State and Local Government	10.8%	10.2%	10.2%	10.1%	10.1%	10.0%	9.9%	9.7%	9.4%	9.1%	8.6%

Table 4-28. Demographic and Employment Baseline Projections for Economic Impact Area LA-2 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	11,484.00	12,782.07	13,132.04	13,420.62	13,715.20	14,015.87	14,322.73	15,953.99	17,757.47	19,748.33	24,357.40
Farm Employment	0.8%	1.5%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.0%	0.9%	0.8%
Forestry, Fishing, Related Activities	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%
Mining	13.7%	17.7%	17.7%	17.8%	17.9%	18.0%	18.1%	18.7%	19.3%	19.9%	21.0%
Utilities	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Construction	7.1%	6.0%	6.3%	6.2%	6.1%	6.0%	5.9%	5.4%	4.9%	4.5%	3.8%
Manufacturing	7.5%	7.6%	7.7%	7.6%	7.5%	7.4%	7.3%	6.8%	6.3%	5.9%	5.1%
Wholesale Trade	4.7%	4.8%	5.0%	4.9%	4.9%	4.9%	4.9%	4.9%	4.8%	4.7%	4.5%
Retail Trade	7.9%	7.7%	7.8%	7.7%	7.7%	7.6%	7.5%	7.3%	7.0%	6.7%	6.2%
Transportation and Warehousing	4.6%	3.8%	3.7%	3.7%	3.7%	3.7%	3.7%	3.6%	3.6%	3.6%	3.5%
Information Employment	1.7%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%
Finance and Insurance	4.1%	2.9%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Real Estate / Rental and Lease	3.5%	2.6%	2.6%	2.6%	2.7%	2.7%	2.7%	2.7%	2.7%	2.8%	2.8%
Professional and Technical Services	6.0%	6.1%	6.1%	6.1%	6.1%	6.2%	6.2%	6.3%	6.4%	6.5%	6.7%
Management	1.6%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.6%	1.7%
Administrative and Waste Services	3.1%	2.9%	2.9%	2.9%	3.0%	3.0%	3.0%	3.1%	3.2%	3.2%	3.4%
Educational Services	0.7%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%
Health Care and Social Assistance	11.3%	11.6%	11.7%	11.8%	12.0%	12.1%	12.2%	12.9%	13.6%	14.3%	15.7%
Arts, Entertainment, and Recreation	0.6%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Accommodation and Food Services	2.5%	2.6%	2.7%	2.7%	2.7%	2.6%	2.6%	2.6%	2.6%	2.6%	2.5%
Other Services, Except Public Administration	4.5%	4.1%	4.1%	4.2%	4.2%	4.2%	4.2%	4.4%	4.5%	4.7%	4.9%
Federal Civilian Government	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.1%	1.0%	0.9%
Federal Military	0.9%	0.9%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%
State and Local Government	11.3%	11.3%	11.2%	11.1%	11.1%	11.1%	11.0%	10.8%	10.6%	10.4%	9.9%
Total Personal Income (in millions of 2005 dollars)											
Total Personal Income Per Capita (in 2005 dollars)	28,507	30,706	30,852	31,247	31,645	32,047	32,456	34,618	37,001	39,634	45,589
Woods & Poole Economics Wealth Index (U.S. = 100)	72.7	78.6	77.7	77.7	77.8	77.8	77.8	77.8	77.7	77.7	77.5
Persons Per Household (in number of people)	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.7
Mean Household Total Personal Income (in 2005 dollars)	68,505	75,359	75,338	76,021	76,720	77,445	78,201	82,488	87,604	93,623	108,360
Total Number of Households (in thousands)	208.17	220.47	222.77	225.63	228.48	231.29	234.07	247.40	259.85	271.19	290.47
Income < $10,000 (thousands of households, 2000 dollars)	15.9%	14.1%	13.9%	13.7%	13.4%	13.2%	13.0%	11.8%	10.4%	8.9%	6.5%
Income $10,000 to $19,999	15.2%	13.6%	13.3%	13.1%	12.9%	12.7%	12.6%	11.3%	10.0%	8.6%	6.3%
Income $20,000 to $29,999	12.9%	11.7%	11.5%	11.3%	11.2%	11.0%	10.8%	9.8%	8.7%	7.5%	5.5%
Income $30,000 to $44,999	18.2%	18.4%	18.3%	18.3%	18.2%	18.1%	18.0%	17.0%	15.5%	13.7%	9.9%
Income $45,000 to $59,999	14.1%	15.8%	16.1%	16.3%	16.5%	16.7%	17.0%	18.2%	18.8%	18.9%	16.5%
Income $60,000 to $74,999	9.1%	10.2%	10.4%	10.6%	10.7%	10.9%	11.0%	12.3%	14.0%	16.2%	19.4%
Income $75,000 to $99,999	7.4%	8.3%	8.5%	8.6%	8.8%	8.9%	9.0%	10.1%	11.5%	13.4%	18.4%
Income $100,000 or more	7.1%	7.9%	8.0%	8.2%	8.3%	8.4%	8.5%	9.6%	11.0%	12.8%	17.5%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 7 parishes in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-29

Demographic and Employment Baseline Projections for Economic Impact Area LA-3

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	1,039.88	1,126.87	1,140.44	1,154.15	1,167.97	1,181.91	1,195.92	1,266.99	1,339.29	1,411.83	1,557.29
Age Under 19 years	29.7%	28.8%	28.6%	28.4%	28.3%	28.1%	28.1%	27.9%	27.6%	27.2%	26.3%
Age 20 to 34	22.4%	23.1%	23.4%	23.5%	23.5%	23.5%	23.1%	21.7%	20.6%	20.2%	20.3%
Age 35 to 49	21.4%	19.2%	18.7%	18.3%	18.0%	17.9%	17.9%	18.4%	19.4%	19.7%	18.1%
Age 50 to 64	16.2%	17.8%	18.1%	18.2%	18.3%	18.3%	18.3%	17.7%	16.3%	15.5%	17.3%
Age 65 and over	10.3%	11.1%	11.3%	11.6%	11.9%	12.2%	12.5%	14.3%	16.1%	17.5%	18.0%
Median Age of Population (in years)	35	35	35	35	35	36	36	37	38	39	40
White Population (in thousands)	65.7%	64.0%	63.7%	63.5%	63.3%	63.1%	62.9%	61.8%	60.7%	59.6%	57.2%
Black Population (in thousands)	29.6%	30.6%	30.7%	30.8%	30.9%	31.0%	31.1%	31.6%	32.0%	32.5%	33.4%
Native American Population (in thousands)	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%	1.1%
Asian and Pacific Islander Population (in thousands)	1.4%	1.4%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.7%	1.8%	2.0%
Hispanic or Latino Population (in thousands)	2.3%	3.0%	3.1%	3.2%	3.3%	3.4%	3.5%	3.9%	4.4%	5.0%	6.2%
Male Population (in thousands)	48.7%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.8%	48.9%	48.8%	48.9%
Total Employment (in thousands of jobs)	606.81	663.02	680.63	689.17	697.80	706.51	715.33	760.83	808.81	859.36	968.53
Farm Employment	0.7%	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%
Forestry, Fishing, Related Activities	0.8%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
Mining	1.5%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.7%	1.6%	1.5%	1.2%
Utilities	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%
Construction	9.8%	9.3%	9.3%	9.3%	9.4%	9.4%	9.5%	9.6%	9.8%	10.0%	10.3%
Manufacturing	6.8%	6.1%	6.1%	6.0%	5.9%	5.8%	5.7%	5.3%	5.0%	4.6%	4.0%
Wholesale Trade	3.2%	2.8%	2.8%	2.8%	2.8%	2.7%	2.7%	2.6%	2.4%	2.3%	2.1%
Retail Trade	10.9%	10.1%	10.0%	10.0%	10.0%	10.0%	10.0%	9.9%	9.7%	9.6%	9.3%
Transportation and Warehousing	4.4%	4.6%	4.5%	4.5%	4.5%	4.5%	4.5%	4.4%	4.3%	4.3%	4.1%
Information Employment	1.4%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.1%	1.0%
Finance and Insurance	3.5%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.2%	3.1%	3.1%	2.9%
Real Estate / Rental and Lease	3.6%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.8%	3.8%	3.8%	3.8%
Professional and Technical Services	4.8%	5.6%	5.6%	5.7%	5.7%	5.7%	5.8%	6.0%	6.1%	6.3%	6.6%
Management	1.0%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	0.9%	0.8%
Administrative and Waste Services	5.8%	6.1%	6.1%	6.2%	6.3%	6.4%	6.5%	7.1%	7.6%	8.2%	9.4%
Educational Services	1.1%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.7%	1.9%	2.1%
Health Care and Social Assistance	8.8%	10.0%	10.1%	10.1%	10.2%	10.3%	10.3%	10.6%	10.9%	11.2%	11.7%
Arts, Entertainment, and Recreation	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%
Accommodation and Food Services	6.6%	6.7%	6.7%	6.8%	6.8%	6.8%	6.8%	6.9%	7.0%	7.1%	7.3%
Other Services, Except Public Administration	6.7%	6.6%	6.7%	6.7%	6.7%	6.8%	6.8%	7.0%	7.2%	7.4%	7.8%
Federal Civilian Government	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%
Federal Military	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%	0.5%
State and Local Government	15.6%	15.0%	14.9%	14.8%	14.7%	14.5%	14.4%	13.8%	13.3%	12.7%	11.6%

Table 4-29. Demographic and Employment Baseline Projections for Economic Impact Area LA-3 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	24,055.56	27,529.09	28,679.63	29,248.86	29,828.55	30,418.91	31,020.09	34,194.93	37,669.23	41,468.73	50,154.87
Farm Employment	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Forestry, Fishing, Related Activities	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Mining	2.6%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%
Utilities	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
Construction	10.3%	11.0%	12.0%	11.9%	11.9%	11.8%	11.7%	11.4%	11.1%	10.8%	10.1%
Manufacturing	12.4%	11.2%	11.3%	11.2%	11.1%	10.9%	10.8%	10.1%	9.5%	8.9%	7.7%
Wholesale Trade	4.4%	3.7%	3.8%	3.7%	3.7%	3.7%	3.7%	3.6%	3.5%	3.4%	3.2%
Retail Trade	7.2%	6.4%	6.4%	6.3%	6.3%	6.3%	6.3%	6.2%	6.1%	6.0%	5.8%
Transportation and Warehousing	6.0%	6.7%	6.7%	6.7%	6.7%	6.6%	6.6%	6.6%	6.5%	6.4%	6.3%
Information Employment	1.7%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
Finance and Insurance	4.3%	3.6%	3.5%	3.5%	3.5%	3.5%	3.5%	3.6%	3.7%	3.8%	4.0%
Real Estate / Rental and Lease	2.1%	1.8%	1.7%	1.7%	1.7%	1.8%	1.8%	1.8%	1.9%	2.0%	2.1%
Professional and Technical Services	6.0%	6.9%	6.8%	6.9%	6.9%	7.0%	7.0%	7.3%	7.6%	7.9%	8.4%
Management	1.4%	1.9%	1.9%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Administrative and Waste Services	3.5%	3.9%	3.8%	3.9%	4.0%	4.1%	4.2%	4.7%	5.2%	5.7%	7.0%
Educational Services	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%	1.0%
Health Care and Social Assistance	9.2%	9.4%	9.3%	9.3%	9.4%	9.5%	9.6%	9.9%	10.3%	10.6%	11.2%
Arts, Entertainment, and Recreation	0.7%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%
Accommodation and Food Services	2.7%	2.6%	2.5%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.7%	2.7%
Other Services, Except Public Administration	4.1%	3.6%	3.5%	3.5%	3.6%	3.6%	3.6%	3.7%	3.8%	3.9%	4.1%
Federal Civilian Government	1.2%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.7%
Federal Military	0.9%	0.9%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
State and Local Government	17.5%	17.8%	17.4%	17.3%	17.3%	17.2%	17.2%	16.9%	16.6%	16.3%	15.6%
Total Personal Income Per Capita (in 2005 dollars)	30,731	32,203	32,690	33,093	33,505	33,924	34,352	36,628	39,151	41,951	48,338
Woods & Poole Economics Wealth Index (U.S. = 100)	79.2	85.3	85.7	85.7	85.8	85.9	86.0	86.4	86.8	87.2	88.0
Persons Per Household (in number of people)	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6
Mean Household Total Personal Income (in 2005 dollars)	77,923	83,219	84,664	85,438	86,256	87,115	88,016	93,155	99,279	106,460	124,061
Total Number of Households (in thousands)	385.14	421.32	426.92	433.61	440.27	446.88	453.43	485.13	515.26	543.37	593.15
Income < $10,000 (thousands of households, 2000 dollars)	12.4%	11.3%	11.1%	10.9%	10.7%	10.6%	10.4%	9.3%	8.2%	7.1%	5.3%
Income $10,000 to $19,999	13.2%	12.1%	11.8%	11.7%	11.5%	11.3%	11.1%	10.0%	8.8%	7.6%	5.7%
Income $20,000 to $29,999	12.1%	11.1%	10.8%	10.7%	10.5%	10.4%	10.2%	9.2%	8.1%	7.0%	5.2%
Income $30,000 to $44,999	17.5%	16.6%	16.3%	16.1%	15.9%	15.7%	15.5%	14.1%	12.4%	10.8%	8.0%
Income $45,000 to $59,999	14.7%	16.0%	16.3%	16.5%	16.7%	16.9%	17.0%	17.3%	16.7%	15.3%	11.7%
Income $60,000 to $74,999	11.1%	12.1%	12.4%	12.7%	12.9%	13.1%	13.3%	15.0%	17.1%	19.0%	19.1%
Income $75,000 to $99,999	10.0%	10.9%	11.1%	11.3%	11.5%	11.7%	11.9%	13.3%	15.3%	17.7%	24.2%
Income $100,000 or more	9.1%	9.8%	10.0%	10.1%	10.3%	10.4%	10.6%	11.8%	13.4%	15.4%	20.8%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 10 parishes in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-30

Demographic and Employment Baseline Projections for Economic Impact Area LA-4

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	1,378.12	1,267.52	1,278.34	1,289.31	1,300.40	1,311.64	1,322.96	1,380.77	1,439.98	1,499.47	1,618.89
Age Under 19 years	28.1%	26.3%	26.2%	26.1%	26.1%	26.1%	26.1%	26.5%	26.3%	25.9%	25.1%
Age 20 to 34	20.7%	20.7%	20.6%	20.5%	20.4%	20.1%	19.9%	18.1%	17.4%	17.5%	18.6%
Age 35 to 49	22.0%	20.1%	19.7%	19.4%	19.2%	19.0%	18.8%	19.1%	19.5%	19.0%	17.2%
Age 50 to 64	17.5%	20.5%	20.8%	20.9%	20.9%	21.0%	20.9%	19.8%	18.0%	17.2%	18.4%
Age 65 and over	11.6%	12.5%	12.7%	13.1%	13.4%	13.8%	14.2%	16.5%	18.8%	20.3%	20.7%
Median Age of Population (in years)	36	36	37	37	37	37	37	38	39	40	41
White Population (in thousands)	54.4%	55.5%	55.3%	55.1%	54.9%	54.8%	54.6%	53.7%	52.8%	51.9%	50.1%
Black Population (in thousands)	37.7%	35.0%	35.0%	35.0%	35.0%	35.1%	35.1%	35.2%	35.3%	35.3%	35.4%
Native American Population (in thousands)	0.4%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Asian and Pacific Islander Population (in thousands)	2.4%	2.7%	2.7%	2.8%	2.8%	2.8%	2.9%	3.1%	3.3%	3.5%	3.7%
Hispanic or Latino Population (in thousands)	5.1%	6.4%	6.5%	6.6%	6.7%	6.9%	7.0%	7.5%	8.1%	8.8%	10.2%
Male Population (in thousands)	48.0%	48.2%	48.2%	48.2%	48.2%	48.2%	48.2%	48.2%	48.2%	48.1%	48.2%
Total Employment (in thousands of jobs)	740.50	728.32	745.53	752.64	759.77	766.93	774.11	810.24	846.71	883.43	957.04
Farm Employment	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%
Forestry, Fishing, Related Activities	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Mining	1.3%	1.5%	1.4%	1.4%	1.4%	1.3%	1.3%	1.2%	1.1%	1.0%	0.8%
Utilities	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Construction	6.2%	7.4%	7.4%	7.5%	7.6%	7.6%	7.7%	8.1%	8.5%	8.9%	9.8%
Manufacturing	5.6%	5.6%	5.5%	5.5%	5.4%	5.3%	5.3%	4.9%	4.6%	4.4%	3.8%
Wholesale Trade	3.6%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.0%	3.0%	2.9%	2.8%
Retail Trade	10.0%	10.2%	10.2%	10.3%	10.3%	10.3%	10.3%	10.5%	10.6%	10.7%	10.9%
Transportation and Warehousing	4.1%	3.8%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.6%	3.6%	3.4%
Information Employment	1.6%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.2%
Finance and Insurance	3.9%	3.5%	3.5%	3.4%	3.4%	3.4%	3.4%	3.3%	3.2%	3.1%	2.9%
Real Estate / Rental and Lease	4.0%	3.9%	3.9%	3.9%	3.9%	4.0%	4.0%	4.0%	4.0%	4.1%	4.1%
Professional and Technical Services	5.7%	6.3%	6.3%	6.3%	6.2%	6.2%	6.2%	6.2%	6.1%	6.1%	5.9%
Management	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%
Administrative and Waste Services	6.4%	6.1%	6.2%	6.2%	6.3%	6.3%	6.3%	6.5%	6.7%	6.8%	7.1%
Educational Services	3.1%	3.2%	3.2%	3.2%	3.2%	3.1%	3.1%	3.1%	3.0%	3.0%	2.8%
Health Care and Social Assistance	8.8%	9.6%	9.7%	9.7%	9.8%	9.8%	9.9%	10.1%	10.4%	10.7%	11.1%
Arts, Entertainment, and Recreation	2.5%	2.4%	2.4%	2.4%	2.4%	2.5%	2.5%	2.5%	2.6%	2.6%	2.7%
Accommodation and Food Services	8.8%	9.1%	9.0%	8.9%	8.9%	8.8%	8.8%	8.4%	8.1%	7.8%	7.3%
Other Services, Except Public Administration	6.5%	6.3%	6.4%	6.4%	6.4%	6.4%	6.5%	6.6%	6.8%	6.9%	7.1%
Federal Civilian Government	2.1%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.5%	1.4%	1.3%
Federal Military	1.4%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	0.9%	0.8%
State and Local Government	11.9%	11.7%	11.7%	11.7%	11.8%	11.8%	11.8%	11.9%	11.9%	11.9%	12.0%

Table 4-30. Demographic and Employment Baseline Projections for Economic Impact Area LA-4 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	33,666.07	33,632.01	34,709.10	35,337.46	35,974.63	36,620.67	37,275.64	40,686.08	44,326.90	48,203.33	56,678.49
Farm Employment	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Forestry, Fishing, Related Activities	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Mining	4.4%	4.9%	4.8%	4.8%	4.8%	4.7%	4.7%	4.6%	4.5%	4.4%	4.1%
Utilities	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%
Construction	6.5%	6.2%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.6%
Manufacturing	8.6%	9.0%	9.2%	9.1%	9.0%	8.9%	8.8%	8.2%	7.8%	7.3%	6.5%
Wholesale Trade	5.3%	4.9%	5.0%	5.0%	5.0%	5.0%	5.0%	4.9%	4.9%	4.9%	4.8%
Retail Trade	6.2%	5.8%	5.8%	5.8%	5.8%	5.8%	5.8%	5.8%	5.8%	5.8%	5.8%
Transportation and Warehousing	5.1%	4.9%	4.8%	4.8%	4.8%	4.7%	4.7%	4.6%	4.5%	4.4%	4.2%
Information Employment	1.7%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%
Finance and Insurance	5.1%	4.2%	4.2%	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%
Real Estate / Rental and Lease	2.6%	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.3%	1.4%
Professional and Technical Services	8.0%	9.0%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.9%	8.8%	8.8%
Management	1.8%	1.7%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%	1.7%	1.8%	1.8%
Administrative and Waste Services	4.0%	3.9%	4.0%	4.1%	4.1%	4.1%	4.2%	4.4%	4.6%	4.8%	5.1%
Educational Services	2.2%	2.5%	2.5%	2.5%	2.5%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
Health Care and Social Assistance	8.7%	9.8%	9.7%	9.8%	9.9%	9.9%	10.0%	10.3%	10.6%	10.9%	11.6%
Arts, Entertainment, and Recreation	2.1%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.1%	2.1%	2.2%	2.2%
Accommodation and Food Services	4.4%	4.8%	4.7%	4.6%	4.6%	4.6%	4.5%	4.3%	4.2%	4.0%	3.7%
Other Services, Except Public Administration	3.7%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.7%	3.8%	3.9%	4.0%
Federal Civilian Government	4.2%	4.0%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.8%	3.8%
Federal Military	1.8%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
State and Local Government	12.1%	13.0%	12.9%	12.9%	13.0%	13.0%	13.1%	13.4%	13.7%	14.0%	14.5%
Total Personal Income Per Capita (in 2005 dollars)	32,677	35,414	35,829	36,225	36,628	37,038	37,456	39,644	42,012	44,580	50,228
Woods & Poole Economics Wealth Index (U.S. = 100)	79.1	91.9	91.0	90.8	90.7	90.5	90.4	89.9	89.4	88.9	87.7
Persons Per Household (in number of people)	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5
Mean Household Total Personal Income (in 2005 dollars)	77,994	87,207	87,276	87,772	88,333	88,946	89,614	93,616	98,555	104,400	118,602
Total Number of Households (in thousands)	530.24	491.36	496.01	501.93	507.80	513.61	519.34	546.73	572.34	595.76	635.83
Income < $10,000 (thousands of households, 2000 dollars)	12.7%	10.8%	10.6%	10.5%	10.3%	10.1%	9.9%	9.2%	8.2%	7.2%	5.5%
Income $10,000 to $19,999	13.5%	11.9%	11.7%	11.5%	11.3%	11.1%	10.9%	10.1%	9.1%	8.0%	6.2%
Income $20,000 to $29,999	12.9%	11.4%	11.2%	11.1%	10.9%	10.8%	10.6%	9.7%	8.7%	7.8%	6.1%
Income $30,000 to $44,999	17.6%	15.5%	15.3%	15.2%	15.0%	14.8%	14.6%	13.6%	12.2%	10.8%	8.4%
Income $45,000 to $59,999	13.7%	15.1%	15.3%	15.4%	15.5%	15.6%	15.7%	15.5%	14.9%	14.0%	11.2%
Income $60,000 to $74,999	10.1%	11.7%	11.9%	12.0%	12.2%	12.4%	12.6%	13.8%	15.2%	16.2%	15.7%
Income $75,000 to $99,999	9.3%	11.3%	11.5%	11.7%	11.9%	12.1%	12.3%	13.6%	15.3%	17.4%	22.5%
Income $100,000 or more	10.2%	12.3%	12.5%	12.6%	12.8%	13.1%	13.3%	14.5%	16.4%	18.6%	24.3%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 9 parishes in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-31

Demographic and Employment Baseline Projections for Economic Impact Area MS-1

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	476.88	470.61	474.64	478.72	482.85	487.02	491.23	512.71	534.70	556.77	601.05
Age Under 19 years	28.6%	28.0%	27.9%	27.8%	27.6%	27.6%	27.5%	27.5%	27.3%	26.8%	25.7%
Age 20 to 34	20.2%	20.3%	20.4%	20.5%	20.6%	20.5%	20.2%	19.6%	18.7%	18.5%	19.0%
Age 35 to 49	21.7%	19.8%	19.4%	19.1%	18.8%	18.5%	18.5%	18.3%	18.9%	19.0%	18.0%
Age 50 to 64	17.4%	19.0%	19.3%	19.3%	19.3%	19.4%	19.5%	18.9%	17.6%	16.8%	17.7%
Age 65 and over	12.1%	12.8%	13.0%	13.4%	13.7%	14.0%	14.3%	15.7%	17.5%	18.9%	19.6%
Median Age of Population (in years)	36	36	36	36	37	37	37	37	38	39	40
White Population (in thousands)	75.5%	74.0%	73.8%	73.7%	73.5%	73.4%	73.2%	72.5%	71.8%	71.1%	70.0%
Black Population (in thousands)	19.2%	19.8%	19.8%	19.9%	19.9%	19.9%	20.0%	20.3%	20.5%	20.8%	21.3%
Native American Population (in thousands)	0.5%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%
Asian and Pacific Islander Population (in thousands)	2.0%	2.1%	2.1%	2.2%	2.2%	2.2%	2.2%	2.3%	2.3%	2.3%	2.3%
Hispanic or Latino Population (in thousands)	2.8%	3.6%	3.7%	3.8%	3.8%	3.9%	4.0%	4.4%	4.8%	5.2%	5.9%
Male Population (in thousands)	49.6%	49.6%	49.6%	49.6%	49.6%	49.5%	49.5%	49.5%	49.6%	49.6%	49.6%
Total Employment (in thousands of jobs)	238.83	243.91	249.36	251.56	253.76	255.98	258.22	269.62	281.38	293.52	318.92
Farm Employment	1.4%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%	1.1%	1.0%	0.9%
Forestry, Fishing, Related Activities	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%
Mining	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Utilities	0.9%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Construction	7.5%	7.2%	7.2%	7.2%	7.2%	7.3%	7.3%	7.4%	7.5%	7.7%	7.9%
Manufacturing	9.5%	10.2%	10.2%	10.1%	10.0%	9.9%	9.8%	9.4%	9.0%	8.6%	7.9%
Wholesale Trade	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.2%	1.1%
Retail Trade	10.9%	10.2%	10.1%	10.1%	10.1%	10.1%	10.0%	9.9%	9.8%	9.7%	9.4%
Transportation and Warehousing	2.4%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.6%	2.6%	2.6%
Information Employment	1.4%	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%	1.1%
Finance and Insurance	2.5%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
Real Estate / Rental and Lease	3.1%	3.5%	3.5%	3.5%	3.6%	3.6%	3.6%	3.8%	3.9%	4.0%	4.3%
Professional and Technical Services	3.8%	4.1%	4.2%	4.2%	4.2%	4.3%	4.3%	4.5%	4.8%	5.0%	5.4%
Management	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%
Administrative and Waste Services	5.4%	6.0%	6.1%	6.1%	6.2%	6.3%	6.4%	6.8%	7.2%	7.6%	8.4%
Educational Services	0.5%	0.8%	0.8%	0.9%	0.9%	0.9%	0.9%	1.0%	1.1%	1.2%	1.4%
Health Care and Social Assistance	6.2%	6.8%	6.9%	6.9%	6.9%	7.0%	7.0%	7.1%	7.2%	7.3%	7.5%
Arts, Entertainment, and Recreation	2.2%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%
Accommodation and Food Services	12.1%	10.3%	10.3%	10.3%	10.2%	10.2%	10.2%	10.0%	9.8%	9.6%	9.3%
Other Services, Except Public Administration	5.5%	5.5%	5.6%	5.6%	5.6%	5.7%	5.7%	5.9%	6.1%	6.3%	6.7%
Federal Civilian Government	3.9%	4.0%	4.0%	3.9%	3.9%	3.9%	3.8%	3.7%	3.5%	3.4%	3.1%
Federal Military	5.7%	5.3%	5.3%	5.2%	5.2%	5.1%	5.1%	4.8%	4.6%	4.3%	3.9%
State and Local Government	12.3%	13.4%	13.4%	13.4%	13.4%	13.4%	13.3%	13.3%	13.2%	13.1%	13.0%

Table 4-31. Demographic and Employment Baseline Projections for Economic Impact Area MS-1 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	9,318.99	9,816.16	10,180.77	10,354.51	10,530.94	10,710.09	10,892.03	11,844.59	12,872.19	13,979.85	16,456.60
Farm Employment	0.3%	0.0%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Forestry, Fishing, Related Activities	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%
Mining	0.2%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Utilities	2.1%	1.6%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.8%	1.9%	2.0%
Construction	6.0%	5.4%	6.0%	6.0%	5.9%	5.9%	5.8%	5.7%	5.5%	5.3%	5.0%
Manufacturing	15.4%	17.3%	17.7%	17.5%	17.4%	17.3%	17.1%	16.5%	15.8%	15.1%	13.9%
Wholesale Trade	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.5%	1.5%	1.4%	1.3%
Retail Trade	7.0%	6.1%	6.1%	6.0%	6.0%	6.0%	5.9%	5.8%	5.7%	5.5%	5.3%
Transportation and Warehousing	2.3%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Information Employment	1.4%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%	0.9%	1.0%	1.1%
Finance and Insurance	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.3%	2.4%	2.5%	2.6%
Real Estate / Rental and Lease	1.0%	0.7%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%	0.9%	1.0%	1.1%
Professional and Technical Services	4.6%	5.1%	5.1%	5.2%	5.3%	5.3%	5.4%	5.7%	6.0%	6.3%	6.9%
Management	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
Administrative and Waste Services	3.1%	3.4%	3.4%	3.5%	3.5%	3.6%	3.6%	3.9%	4.2%	4.5%	5.2%
Educational Services	0.3%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.6%	0.6%	0.7%	0.9%
Health Care and Social Assistance	6.7%	6.9%	6.9%	6.9%	6.9%	7.0%	7.0%	7.1%	7.3%	7.4%	7.6%
Arts, Entertainment, and Recreation	1.5%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%
Accommodation and Food Services	8.0%	5.9%	5.8%	5.8%	5.7%	5.7%	5.7%	5.6%	5.4%	5.3%	5.1%
Other Services, Except Public Administration	3.4%	3.5%	3.4%	3.4%	3.5%	3.5%	3.5%	3.6%	3.8%	3.9%	4.1%
Federal Civilian Government	8.4%	8.8%	8.6%	8.6%	8.6%	8.6%	8.6%	8.6%	8.5%	8.5%	8.4%
Federal Military	10.2%	10.2%	10.1%	10.0%	10.0%	10.0%	9.9%	9.8%	9.6%	9.5%	9.2%
State and Local Government	13.2%	15.3%	15.0%	15.0%	15.1%	15.1%	15.2%	15.4%	15.5%	15.7%	16.1%
Total Personal Income Per Capita (in 2005 dollars)	27,815	29,510	29,900	30,216	30,539	30,868	31,204	32,989	34,961	37,140	42,045
Woods & Poole Economics Wealth Index (U.S. = 100)	68.6	73.6	73.5	73.4	73.4	73.3	73.2	72.8	72.4	72.0	71.2
Persons Per Household (in number of people)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.6
Mean Household Total Personal Income (in 2005 dollars)	65,960	67,129	67,940	68,417	68,918	69,445	70,003	73,247	77,212	81,941	93,603
Total Number of Households (in thousands)	180.00	179.76	181.51	183.72	185.92	188.09	190.24	200.49	210.03	218.68	233.44
Income < $10,000 (thousands of households, 2000 dollars)	10.8%	9.8%	9.7%	9.5%	9.4%	9.2%	9.1%	8.4%	7.4%	6.4%	4.6%
Income $10,000 to $19,999	122.2%	122.3%	122.3%	122.3%	122.3%	122.3%	122.3%	122.5%	122.6%	122.8%	122.9%
Income $20,000 to $29,999	103.6%	102.5%	102.4%	102.4%	102.4%	102.4%	102.4%	101.9%	101.3%	101.1%	100.9%
Income $30,000 to $44,999	148.8%	154.6%	155.9%	156.8%	157.6%	158.3%	158.9%	161.1%	162.6%	163.1%	163.2%
Income $45,000 to $59,999	79.1%	92.0%	94.5%	96.5%	98.6%	100.9%	103.3%	115.9%	132.2%	147.5%	162.6%
Income $60,000 to $74,999	65.2%	66.6%	66.8%	66.9%	67.1%	67.3%	67.4%	71.0%	80.1%	94.1%	134.9%
Income $75,000 to $99,999	83.1%	82.9%	82.9%	82.9%	82.9%	82.8%	82.8%	82.7%	82.7%	84.6%	103.1%
Income $100,000 or more	81.1%	81.1%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.0%	81.1%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 7 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-32

Demographic and Employment Baseline Projections for Economic Impact Area AL-1

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	691.71	725.48	731.11	736.83	742.62	748.49	754.41	784.68	815.74	846.94	909.54
Age Under 19 years	28.1%	27.4%	27.2%	27.1%	26.9%	26.8%	26.7%	26.5%	26.1%	25.6%	24.6%
Age 20 to 34	19.2%	19.5%	19.6%	19.6%	19.5%	19.3%	19.1%	18.3%	17.7%	17.3%	17.6%
Age 35 to 49	21.1%	19.3%	18.9%	18.6%	18.5%	18.4%	18.4%	18.5%	18.8%	18.6%	17.8%
Age 50 to 64	18.0%	19.5%	19.7%	19.8%	19.8%	19.8%	19.8%	19.0%	17.6%	17.1%	17.9%
Age 65 and over	13.6%	14.4%	14.6%	14.9%	15.3%	15.6%	16.0%	17.7%	19.8%	21.3%	22.1%
Median Age of Population (in years)	38	39	39	40	40	40	40	41	42	42	44
White Population (in thousands)	66.6%	66.0%	65.9%	65.9%	65.8%	65.7%	65.7%	65.3%	64.9%	64.4%	63.7%
Black Population (in thousands)	29.6%	29.4%	29.4%	29.4%	29.3%	29.3%	29.3%	29.3%	29.3%	29.3%	29.1%
Native American Population (in thousands)	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%	1.0%
Asian and Pacific Islander Population (in thousands)	1.2%	1.5%	1.5%	1.5%	1.6%	1.6%	1.6%	1.7%	1.9%	2.0%	2.3%
Hispanic or Latino Population (in thousands)	1.6%	2.2%	2.3%	2.3%	2.4%	2.4%	2.5%	2.7%	3.0%	3.3%	4.0%
Male Population (in thousands)	48.2%	48.3%	48.3%	48.3%	48.3%	48.3%	48.4%	48.4%	48.5%	48.5%	48.6%
Total Employment (in thousands of jobs)	363.84	353.63	362.59	366.69	370.81	374.97	379.15	400.55	422.75	445.72	493.98
Farm Employment	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.2%	1.2%	1.1%
Forestry, Fishing, Related Activities	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.8%	0.8%
Mining	0.3%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Utilities	0.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%
Construction	8.5%	7.5%	7.6%	7.6%	7.6%	7.6%	7.6%	7.7%	7.7%	7.7%	7.8%
Manufacturing	8.7%	7.6%	7.6%	7.5%	7.4%	7.3%	7.2%	6.9%	6.5%	6.2%	5.5%
Wholesale Trade	3.5%	3.1%	3.0%	3.0%	3.0%	3.0%	2.9%	2.8%	2.7%	2.6%	2.4%
Retail Trade	12.4%	11.9%	11.8%	11.8%	11.7%	11.6%	11.5%	11.1%	10.7%	10.3%	9.5%
Transportation and Warehousing	3.7%	3.9%	3.9%	3.8%	3.8%	3.8%	3.8%	3.6%	3.5%	3.4%	3.2%
Information Employment	1.3%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.9%
Finance and Insurance	3.4%	3.7%	3.7%	3.7%	3.7%	3.6%	3.6%	3.5%	3.4%	3.2%	3.0%
Real Estate / Rental and Lease	4.4%	4.6%	4.7%	4.7%	4.7%	4.7%	4.8%	4.9%	5.0%	5.2%	5.4%
Professional and Technical Services	4.4%	4.6%	4.7%	4.7%	4.7%	4.8%	4.8%	5.0%	5.2%	5.4%	5.7%
Management	0.2%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Administrative and Waste Services	6.4%	6.4%	6.5%	6.5%	6.6%	6.7%	6.7%	7.0%	7.3%	7.6%	8.3%
Educational Services	1.4%	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.8%	1.9%	2.0%	2.2%
Health Care and Social Assistance	8.5%	9.4%	9.4%	9.5%	9.6%	9.6%	9.7%	10.1%	10.4%	10.7%	11.4%
Arts, Entertainment, and Recreation	1.3%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Accommodation and Food Services	6.8%	7.6%	7.6%	7.7%	7.7%	7.7%	7.8%	8.0%	8.2%	8.4%	8.9%
Other Services, Except Public Administration	7.7%	7.9%	7.9%	8.0%	8.0%	8.1%	8.1%	8.4%	8.7%	8.9%	9.4%
Federal Civilian Government	0.9%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%	0.7%	0.6%
Federal Military	1.3%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%	0.8%	0.7%
State and Local Government	12.0%	12.0%	12.0%	11.9%	11.9%	11.9%	11.8%	11.6%	11.4%	11.1%	10.7%

Table 4-32. Demographic and Employment Baseline Projections for Economic Impact Area AL-1 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	12,930.79	13,040.20	13,381.74	13,639.05	13,900.74	14,166.88	14,437.55	15,860.94	17,407.25	19,085.19	22,872.66
Farm Employment	0.8%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.4%
Forestry, Fishing, Related Activities	1.0%	1.0%	1.0%	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%	0.8%	0.7%
Mining	0.4%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%	0.7%	0.8%
Utilities	1.0%	1.4%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.2%
Construction	8.9%	7.9%	8.6%	8.5%	8.4%	8.4%	8.3%	8.0%	7.7%	7.4%	6.8%
Manufacturing	13.6%	12.2%	12.6%	12.5%	12.4%	12.3%	12.2%	11.7%	11.2%	10.7%	9.8%
Wholesale Trade	5.1%	4.6%	4.7%	4.7%	4.6%	4.6%	4.6%	4.5%	4.4%	4.3%	4.0%
Retail Trade	8.9%	8.4%	8.5%	8.4%	8.3%	8.3%	8.2%	7.9%	7.5%	7.2%	6.5%
Transportation and Warehousing	4.8%	5.7%	5.6%	5.6%	5.6%	5.5%	5.5%	5.3%	5.1%	4.9%	4.6%
Information Employment	1.6%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.3%	1.3%	1.3%
Finance and Insurance	4.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.8%
Real Estate / Rental and Lease	2.3%	1.7%	1.8%	1.8%	1.8%	1.8%	1.8%	2.0%	2.1%	2.2%	2.5%
Professional and Technical Services	5.5%	6.1%	6.1%	6.2%	6.2%	6.3%	6.4%	6.7%	7.0%	7.3%	7.9%
Management	0.3%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%	0.7%	0.8%
Administrative and Waste Services	3.7%	3.6%	3.7%	3.7%	3.7%	3.8%	3.8%	4.1%	4.3%	4.6%	5.1%
Educational Services	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.1%	1.1%	1.2%	1.3%
Health Care and Social Assistance	9.8%	11.0%	11.1%	11.2%	11.3%	11.4%	11.5%	11.9%	12.4%	12.9%	13.8%
Arts, Entertainment, and Recreation	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
Accommodation and Food Services	3.2%	3.5%	3.5%	3.5%	3.5%	3.6%	3.6%	3.7%	3.7%	3.8%	4.0%
Other Services, Except Public Administration	4.8%	4.9%	4.9%	4.9%	4.9%	5.0%	5.0%	5.2%	5.4%	5.5%	5.8%
Federal Civilian Government	2.2%	2.5%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Federal Military	1.8%	1.8%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%
State and Local Government	13.8%	15.2%	15.1%	15.1%	15.1%	15.1%	15.2%	15.2%	15.2%	15.2%	15.1%
Total Personal Income Per Capita (in 2005 dollars)	26,961	28,132	28,252	28,605	28,964	29,329	29,701	31,665	33,826	36,202	41,511
Woods & Poole Economics Wealth Index (U.S. = 100)	69.0	71.9	71.2	71.2	71.3	71.3	71.4	71.6	71.8	72.0	72.2
Persons Per Household (in number of people)	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mean Household Total Personal Income (in 2005 dollars)	61,397	63,756	63,690	64,304	64,944	65,612	66,308	70,242	74,885	80,263	93,095
Total Number of Households (in thousands)	267.98	283.15	285.62	288.82	292.00	295.14	298.23	312.96	326.65	339.07	360.09
Income < $10,000 (thousands of households, 2000 dollars)	13.3%	11.9%	11.7%	11.6%	11.4%	11.2%	11.0%	10.0%	8.6%	7.4%	5.4%
Income $10,000 to $19,999	14.5%	13.2%	13.0%	12.8%	12.7%	12.5%	12.3%	11.2%	9.7%	8.3%	6.2%
Income $20,000 to $29,999	13.0%	11.9%	11.8%	11.6%	11.5%	11.3%	11.2%	10.2%	8.9%	7.7%	5.7%
Income $30,000 to $44,999	18.8%	18.5%	18.4%	18.2%	18.1%	17.9%	17.8%	16.5%	14.6%	12.6%	9.4%
Income $45,000 to $59,999	14.8%	16.4%	16.6%	16.8%	17.0%	17.2%	17.4%	18.7%	19.5%	18.8%	14.8%
Income $60,000 to $74,999	9.6%	10.6%	10.7%	10.9%	11.0%	11.2%	11.3%	12.5%	14.4%	16.8%	19.9%
Income $75,000 to $99,999	8.4%	9.3%	9.4%	9.5%	9.7%	9.8%	9.9%	11.0%	12.7%	14.9%	20.1%
Income $100,000 or more	7.5%	8.4%	8.5%	8.6%	8.7%	8.9%	9.0%	10.0%	11.6%	13.5%	18.4%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 8 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-33

Demographic and Employment Baseline Projections for Economic Impact Area FL-1

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	865.12	896.10	911.70	927.40	943.19	959.08	975.02	1,055.59	1,137.26	1,219.22	1,383.66
Age Under 19 years	26.1%	25.0%	24.8%	24.7%	24.6%	24.5%	24.5%	24.9%	24.7%	24.2%	23.1%
Age 20 to 34	20.5%	21.5%	21.7%	21.8%	21.9%	21.9%	21.5%	19.9%	18.5%	18.2%	18.9%
Age 35 to 49	22.0%	19.5%	19.0%	18.5%	18.1%	17.7%	17.7%	18.2%	19.5%	19.7%	17.0%
Age 50 to 64	17.9%	19.4%	19.6%	19.7%	19.7%	19.8%	19.8%	18.8%	16.9%	15.5%	17.2%
Age 65 and over	13.4%	14.6%	14.8%	15.3%	15.7%	16.1%	16.4%	18.2%	20.4%	22.4%	23.8%
Median Age of Population (in years)	39	39	40	40	40	40	40	40	41	42	43
White Population (in thousands)	79.2%	77.6%	77.4%	77.2%	77.1%	76.9%	76.7%	75.8%	74.9%	74.1%	72.6%
Black Population (in thousands)	13.8%	14.3%	14.3%	14.3%	14.4%	14.4%	14.4%	14.6%	14.7%	14.8%	14.9%
Native American Population (in thousands)	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.8%
Asian and Pacific Islander Population (in thousands)	2.4%	2.6%	2.6%	2.6%	2.7%	2.7%	2.7%	2.8%	2.8%	2.8%	2.6%
Hispanic or Latino Population (in thousands)	3.7%	4.6%	4.7%	4.8%	5.0%	5.1%	5.2%	5.9%	6.6%	7.4%	9.0%
Male Population (in thousands)	49.8%	50.0%	50.1%	50.1%	50.2%	50.2%	50.2%	50.4%	50.5%	50.7%	51.1%
Total Employment (in thousands of jobs)	487.45	489.82	504.24	512.13	520.13	528.26	536.52	579.78	626.48	676.88	789.79
Farm Employment	0.5%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%
Forestry, Fishing, Related Activities	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Mining	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
Utilities	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%
Construction	9.0%	5.6%	5.6%	5.7%	5.7%	5.7%	5.7%	5.7%	5.8%	5.8%	5.9%
Manufacturing	3.4%	3.0%	3.0%	3.0%	3.0%	3.0%	2.9%	2.8%	2.7%	2.6%	2.4%
Wholesale Trade	2.6%	2.1%	2.1%	2.1%	2.0%	2.0%	2.0%	1.9%	1.8%	1.8%	1.6%
Retail Trade	12.0%	11.8%	11.8%	11.7%	11.7%	11.7%	11.7%	11.5%	11.4%	11.3%	10.9%
Transportation and Warehousing	1.8%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	1.9%	1.9%
Information Employment	1.9%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.7%	1.7%	1.7%	1.6%
Finance and Insurance	3.6%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	4.0%	4.1%	4.1%	4.2%
Real Estate / Rental and Lease	5.5%	5.6%	5.6%	5.6%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
Professional and Technical Services	5.2%	5.7%	5.7%	5.8%	5.9%	5.9%	6.0%	6.4%	6.8%	7.1%	8.0%
Management	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%
Administrative and Waste Services	7.0%	6.4%	6.4%	6.5%	6.5%	6.6%	6.7%	6.9%	7.2%	7.4%	7.9%
Educational Services	1.0%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.3%	1.3%	1.4%
Health Care and Social Assistance	8.9%	10.8%	10.9%	11.0%	11.1%	11.2%	11.3%	11.8%	12.4%	12.9%	14.0%
Arts, Entertainment, and Recreation	1.7%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	2.0%	2.0%	2.0%
Accommodation and Food Services	8.8%	9.2%	9.2%	9.2%	9.2%	9.2%	9.2%	9.1%	9.1%	9.1%	9.0%
Other Services, Except Public Administration	6.2%	6.3%	6.3%	6.3%	6.3%	6.3%	6.4%	6.5%	6.5%	6.6%	6.7%
Federal Civilian Government	3.5%	3.7%	3.7%	3.7%	3.6%	3.6%	3.5%	3.3%	3.1%	2.9%	2.5%
Federal Military	6.9%	7.3%	7.2%	7.1%	7.0%	6.9%	6.8%	6.2%	5.7%	5.2%	4.4%
State and Local Government	9.1%	9.7%	9.7%	9.6%	9.6%	9.6%	9.5%	9.3%	9.1%	8.9%	8.4%

Table 4-33. Demographic and Employment Baseline Projections for Economic Impact Area FL-1 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	19,144.97	18,366.21	19,090.88	19,571.64	20,064.69	20,570.39	21,089.01	23,888.71	27,067.17	30,676.87	39,438.19
Farm Employment	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Forestry, Fishing, Related Activities	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Mining	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Utilities	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Construction	8.1%	4.4%	4.8%	4.8%	4.7%	4.7%	4.6%	4.4%	4.2%	4.0%	3.7%
Manufacturing	4.8%	4.7%	4.8%	4.8%	4.8%	4.8%	4.7%	4.6%	4.5%	4.4%	4.2%
Wholesale Trade	3.0%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.3%	2.2%	2.2%	2.0%
Retail Trade	7.9%	7.3%	7.3%	7.3%	7.2%	7.2%	7.2%	7.0%	6.9%	6.7%	6.4%
Transportation and Warehousing	1.8%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%
Information Employment	2.4%	2.0%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Finance and Insurance	3.9%	3.6%	3.6%	3.6%	3.7%	3.7%	3.8%	4.0%	4.2%	4.4%	4.9%
Real Estate / Rental and Lease	3.1%	2.0%	2.0%	2.1%	2.1%	2.1%	2.1%	2.2%	2.3%	2.4%	2.5%
Professional and Technical Services	6.6%	6.8%	6.8%	6.9%	7.0%	7.1%	7.2%	7.7%	8.2%	8.8%	9.9%
Management	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%
Administrative and Waste Services	4.5%	3.7%	3.8%	3.8%	3.9%	3.9%	3.9%	4.2%	4.4%	4.6%	5.1%
Educational Services	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.8%	0.9%	0.9%
Health Care and Social Assistance	10.0%	12.0%	12.0%	12.2%	12.3%	12.5%	12.6%	13.3%	14.0%	14.7%	16.2%
Arts, Entertainment, and Recreation	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Accommodation and Food Services	4.6%	4.4%	4.4%	4.4%	4.4%	4.4%	4.3%	4.3%	4.3%	4.3%	4.2%
Other Services, Except Public Administration	4.4%	4.3%	4.2%	4.2%	4.3%	4.3%	4.3%	4.4%	4.4%	4.5%	4.6%
Federal Civilian Government	6.8%	7.8%	7.6%	7.6%	7.5%	7.5%	7.4%	7.1%	6.8%	6.6%	6.0%
Federal Military	14.5%	18.2%	18.0%	17.8%	17.6%	17.4%	17.2%	16.3%	15.4%	14.5%	12.8%
State and Local Government	10.5%	11.2%	11.1%	11.1%	11.0%	11.0%	11.0%	11.0%	10.9%	10.7%	10.4%
Total Personal Income Per Capita (in 2005 dollars)	30,955	31,238	31,611	31,972	32,345	32,728	33,123	35,252	37,665	40,392	46,766
Woods & Poole Economics Wealth Index (U.S. = 100)	86.0	86.1	85.9	86.0	86.0	86.1	86.2	86.6	87.2	87.8	89.2
Persons Per Household (in number of people)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.5
Mean Household Total Personal Income (in 2005 dollars)	70,630	68,775	69,464	70,092	70,758	71,474	72,225	76,569	81,867	88,167	103,926
Total Number of Households (in thousands)	339.50	355.60	362.19	369.74	377.31	384.77	392.23	428.80	464.20	497.98	559.96
Income < $10,000 (thousands of households, 2000 dollars)	8.7%	8.1%	7.9%	7.8%	7.7%	7.5%	7.4%	6.6%	5.7%	4.9%	3.5%
Income $10,000 to $19,999	12.4%	11.6%	11.3%	11.1%	11.0%	10.8%	10.6%	9.4%	8.1%	7.0%	5.1%
Income $20,000 to $29,999	13.8%	12.9%	12.6%	12.4%	12.2%	12.0%	11.8%	10.4%	9.1%	7.8%	5.7%
Income $30,000 to $44,999	19.7%	18.9%	18.6%	18.3%	18.1%	17.8%	17.5%	15.6%	13.6%	11.7%	8.5%
Income $45,000 to $59,999	16.5%	17.4%	17.8%	18.0%	18.2%	18.3%	18.5%	19.1%	18.7%	17.1%	12.7%
Income $60,000 to $74,999	11.2%	12.0%	12.3%	12.5%	12.7%	13.0%	13.2%	15.0%	17.3%	19.3%	20.1%
Income $75,000 to $99,999	9.2%	9.8%	10.1%	10.2%	10.4%	10.6%	10.8%	12.3%	14.2%	16.5%	22.7%
Income $100,000 or more	8.6%	9.2%	9.5%	9.6%	9.8%	10.0%	10.2%	11.6%	13.4%	15.7%	21.7%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 7 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-34

Demographic and Employment Baseline Projections for Economic Impact Area FL-2

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	613.83	657.40	666.76	676.21	685.71	695.29	704.90	753.56	802.95	852.48	951.77
Age Under 19 years	25.8%	24.6%	24.3%	24.2%	24.0%	23.9%	24.0%	24.2%	24.0%	23.7%	22.9%
Age 20 to 34	24.5%	25.3%	25.6%	25.8%	25.9%	25.9%	25.5%	22.8%	20.4%	19.9%	20.2%
Age 35 to 49	20.7%	18.9%	18.5%	18.1%	17.8%	17.5%	17.4%	18.7%	20.7%	21.4%	17.3%
Age 50 to 64	17.1%	18.2%	18.4%	18.3%	18.3%	18.3%	18.3%	17.6%	16.4%	15.2%	18.4%
Age 65 and over	11.9%	12.9%	13.2%	13.6%	14.0%	14.4%	14.8%	16.7%	18.5%	19.8%	21.2%
Median Age of Population (in years)	37	38	38	38	39	39	39	40	41	42	43
White Population (in thousands)	66.6%	65.2%	65.0%	64.8%	64.6%	64.4%	64.2%	63.2%	62.2%	61.2%	59.5%
Black Population (in thousands)	27.1%	27.5%	27.6%	27.6%	27.7%	27.7%	27.8%	28.2%	28.5%	28.9%	29.5%
Native American Population (in thousands)	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%
Asian and Pacific Islander Population (in thousands)	1.3%	1.5%	1.5%	1.5%	1.6%	1.6%	1.6%	1.7%	1.9%	2.0%	2.2%
Hispanic or Latino Population (in thousands)	4.5%	5.3%	5.4%	5.5%	5.6%	5.8%	5.9%	6.4%	6.9%	7.5%	8.4%
Male Population (in thousands)	50.3%	50.8%	50.8%	50.9%	50.9%	51.0%	51.0%	51.2%	51.3%	51.4%	51.6%
Total Employment (in thousands of jobs)	322.62	330.09	338.56	342.74	346.98	351.28	355.62	378.16	402.13	427.62	483.55
Farm Employment	2.6%	3.0%	3.0%	3.0%	2.9%	2.9%	2.9%	2.7%	2.5%	2.4%	2.1%
Forestry, Fishing, Related Activities	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
Mining	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
Utilities	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%
Construction	6.5%	4.7%	4.7%	4.8%	4.8%	4.8%	4.8%	4.9%	5.0%	5.0%	5.1%
Manufacturing	4.6%	3.6%	3.6%	3.6%	3.5%	3.5%	3.5%	3.3%	3.2%	3.1%	2.8%
Wholesale Trade	2.1%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.7%	1.7%	1.6%	1.4%
Retail Trade	11.0%	10.3%	10.2%	10.2%	10.2%	10.2%	10.2%	10.0%	9.9%	9.8%	9.5%
Transportation and Warehousing	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%
Information Employment	1.8%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.5%	1.5%	1.3%
Finance and Insurance	3.2%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.6%
Real Estate / Rental and Lease	3.1%	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.3%	3.3%	3.4%	3.4%
Professional and Technical Services	5.8%	6.2%	6.3%	6.4%	6.5%	6.6%	6.7%	7.1%	7.6%	8.1%	9.1%
Management	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Administrative and Waste Services	4.8%	4.8%	4.8%	4.9%	4.9%	4.9%	5.0%	5.1%	5.3%	5.4%	5.7%
Educational Services	1.1%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%	1.9%	2.0%	2.2%	2.6%
Health Care and Social Assistance	8.6%	10.3%	10.4%	10.5%	10.7%	10.8%	10.9%	11.4%	12.0%	12.5%	13.6%
Arts, Entertainment, and Recreation	1.2%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.7%	1.7%
Accommodation and Food Services	6.7%	6.8%	6.8%	6.9%	6.9%	6.9%	6.9%	7.0%	7.2%	7.3%	7.5%
Other Services, Except Public Administration	6.2%	6.1%	6.1%	6.1%	6.2%	6.2%	6.2%	6.3%	6.3%	6.4%	6.5%
Federal Civilian Government	1.2%	1.3%	1.3%	1.3%	1.2%	1.2%	1.2%	1.1%	1.1%	1.0%	0.8%
Federal Military	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%
State and Local Government	25.3%	25.0%	24.8%	24.6%	24.4%	24.2%	24.0%	23.0%	22.0%	21.0%	19.2%

Table 4-34. Demographic and Employment Baseline Projections for Economic Impact Area FL-2 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	11,927.62	11,506.58	11,863.49	12,113.72	12,369.19	12,629.96	12,896.15	14,312.49	15,882.28	17,622.00	21,685.31
Farm Employment	1.3%	1.2%	1.3%	1.2%	1.2%	1.2%	1.2%	1.1%	1.0%	0.9%	0.7%
Forestry, Fishing, Related Activities	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.1%	1.0%
Mining	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Utilities	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%	0.9%	0.9%	1.0%
Construction	6.4%	4.2%	4.5%	4.4%	4.4%	4.4%	4.4%	4.2%	4.1%	3.9%	3.6%
Manufacturing	5.9%	5.3%	5.5%	5.4%	5.4%	5.4%	5.4%	5.2%	5.1%	4.9%	4.6%
Wholesale Trade	2.7%	2.3%	2.4%	2.4%	2.4%	2.4%	2.3%	2.3%	2.2%	2.1%	1.9%
Retail Trade	7.2%	7.0%	7.0%	7.0%	6.9%	6.9%	6.9%	6.7%	6.6%	6.4%	6.1%
Transportation and Warehousing	1.5%	1.6%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.5%	1.5%
Information Employment	2.4%	2.3%	2.3%	2.3%	2.3%	2.3%	2.3%	2.2%	2.1%	2.0%	1.9%
Finance and Insurance	4.2%	4.5%	4.6%	4.6%	4.7%	4.7%	4.8%	5.0%	5.2%	5.4%	5.9%
Real Estate / Rental and Lease	1.1%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%
Professional and Technical Services	7.9%	8.1%	8.1%	8.2%	8.3%	8.4%	8.6%	9.2%	9.8%	10.4%	11.7%
Management	0.4%	0.5%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%
Administrative and Waste Services	2.7%	2.7%	2.7%	2.7%	2.8%	2.8%	2.8%	2.9%	3.0%	3.1%	3.4%
Educational Services	0.5%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%	0.9%	1.0%	1.1%	1.4%
Health Care and Social Assistance	9.6%	11.6%	11.7%	11.8%	12.0%	12.1%	12.2%	12.9%	13.5%	14.1%	15.4%
Arts, Entertainment, and Recreation	0.4%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Accommodation and Food Services	2.7%	2.8%	2.7%	2.7%	2.7%	2.8%	2.8%	2.8%	2.8%	2.8%	2.9%
Other Services, Except Public Administration	5.2%	5.4%	5.3%	5.3%	5.3%	5.3%	5.4%	5.4%	5.5%	5.5%	5.6%
Federal Civilian Government	2.7%	3.2%	3.2%	3.2%	3.1%	3.1%	3.1%	3.0%	2.9%	2.8%	2.6%
Federal Military	0.5%	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
State and Local Government	32.3%	32.2%	31.6%	31.4%	31.2%	31.0%	30.8%	29.9%	28.9%	27.9%	26.0%
Total Personal Income Per Capita (in 2005 dollars)	27,200	26,656	26,811	27,063	27,321	27,585	27,856	29,328	31,005	32,905	37,298
Woods & Poole Economics Wealth Index (U.S. = 100)	67.0	66.8	66.7	66.6	66.5	66.4	66.3	65.9	65.6	65.4	64.9
Persons Per Household (in number of people)	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5
Mean Household Total Personal Income (in 2005 dollars)	57,688	56,795	57,352	57,724	58,116	58,529	58,970	61,586	64,884	68,883	78,850
Total Number of Households (in thousands)	236.50	255.39	259.32	263.92	268.49	273.05	277.56	299.51	320.40	339.91	374.75
Income < $10,000 (thousands of households, 2000 dollars)	13.6%	12.8%	12.6%	12.4%	12.2%	12.1%	11.9%	11.0%	10.1%	8.9%	6.6%
Income $10,000 to $19,999	14.3%	13.6%	13.4%	13.2%	13.0%	12.8%	12.6%	11.7%	10.7%	9.4%	7.0%
Income $20,000 to $29,999	14.0%	13.3%	13.1%	12.9%	12.7%	12.5%	12.4%	11.5%	10.5%	9.3%	6.9%
Income $30,000 to $44,999	18.7%	18.8%	18.8%	18.8%	18.7%	18.6%	18.5%	17.9%	16.8%	14.9%	11.1%
Income $45,000 to $59,999	14.2%	14.9%	15.2%	15.4%	15.6%	15.8%	16.1%	17.2%	18.3%	19.3%	17.8%
Income $60,000 to $74,999	9.4%	9.9%	10.0%	10.2%	10.3%	10.5%	10.6%	11.5%	12.5%	14.3%	18.6%
Income $75,000 to $99,999	8.2%	8.6%	8.7%	8.8%	8.9%	9.1%	9.2%	9.9%	10.8%	12.4%	16.6%
Income $100,000 or more	7.8%	8.1%	8.3%	8.4%	8.5%	8.6%	8.7%	9.4%	10.2%	11.6%	15.4%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 15 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-35

Demographic and Employment Baseline Projections for Economic Impact Area FL-3

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	3,416.04	3,624.88	3,675.05	3,725.64	3,776.58	3,827.91	3,879.47	4,140.64	4,405.96	4,672.19	5,206.25
Age Under 19 years	24.0%	23.4%	23.3%	23.2%	23.2%	23.1%	23.1%	23.1%	23.2%	23.1%	23.0%
Age 20 to 34	18.9%	19.4%	19.7%	19.8%	19.9%	19.9%	19.8%	19.2%	18.6%	18.3%	18.6%
Age 35 to 49	21.2%	19.6%	19.2%	18.8%	18.5%	18.2%	18.1%	17.9%	18.4%	18.8%	17.8%
Age 50 to 64	18.1%	19.5%	19.8%	19.8%	19.8%	19.9%	19.9%	19.1%	17.5%	16.2%	16.5%
Age 65 and over	17.8%	18.0%	18.1%	18.4%	18.6%	18.9%	19.1%	20.6%	22.3%	23.7%	24.1%
Median Age of Population (in years)	41	41	42	42	42	42	42	43	43	44	44
White Population (in thousands)	74.5%	71.2%	70.7%	70.1%	69.6%	69.1%	68.5%	65.9%	63.3%	60.7%	55.4%
Black Population (in thousands)	11.3%	11.8%	11.9%	12.0%	12.0%	12.1%	12.1%	12.3%	12.5%	12.6%	12.7%
Native American Population (in thousands)	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%
Asian and Pacific Islander Population (in thousands)	2.5%	2.9%	3.0%	3.0%	3.1%	3.2%	3.3%	3.6%	4.0%	4.4%	5.3%
Hispanic or Latino Population (in thousands)	11.4%	13.7%	14.1%	14.5%	14.9%	15.3%	15.8%	17.8%	19.9%	22.0%	26.4%
Male Population (in thousands)	48.7%	48.9%	49.0%	49.0%	49.1%	49.2%	49.2%	49.4%	49.5%	49.6%	49.7%
Total Employment (in thousands of jobs)	1,944.16	1,868.77	1,922.79	1,951.29	1,980.12	2,009.31	2,038.85	2,192.00	2,354.46	2,526.62	2,901.49
Farm Employment	1.0%	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	0.9%	0.8%
Forestry, Fishing, Related Activities	0.5%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%
Mining	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Utilities	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%
Construction	7.3%	4.8%	4.8%	4.9%	4.9%	4.9%	4.9%	5.0%	5.0%	5.1%	5.2%
Manufacturing	5.0%	4.4%	4.3%	4.3%	4.2%	4.1%	4.0%	3.7%	3.4%	3.1%	2.6%
Wholesale Trade	3.4%	3.4%	3.3%	3.3%	3.3%	3.3%	3.3%	3.2%	3.1%	3.1%	2.9%
Retail Trade	11.4%	11.1%	11.1%	11.0%	11.0%	11.0%	11.0%	10.8%	10.6%	10.4%	10.0%
Transportation and Warehousing	2.3%	2.5%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
Information Employment	2.2%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	1.9%	1.9%	1.8%	1.7%
Finance and Insurance	5.8%	5.9%	5.9%	5.9%	5.9%	5.8%	5.8%	5.7%	5.7%	5.6%	5.4%
Real Estate / Rental and Lease	4.5%	4.4%	4.5%	4.5%	4.5%	4.5%	4.5%	4.6%	4.6%	4.7%	4.8%
Professional and Technical Services	6.4%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%	7.4%	7.4%	7.3%
Management	0.8%	1.2%	1.2%	1.2%	1.2%	1.3%	1.3%	1.3%	1.4%	1.4%	1.6%
Administrative and Waste Services	10.8%	7.8%	7.9%	8.0%	8.1%	8.2%	8.2%	8.7%	9.2%	9.6%	10.6%
Educational Services	1.3%	1.7%	1.7%	1.8%	1.8%	1.8%	1.8%	2.0%	2.1%	2.2%	2.5%
Health Care and Social Assistance	10.3%	13.0%	13.1%	13.2%	13.4%	13.5%	13.6%	14.2%	14.8%	15.4%	16.7%
Arts, Entertainment, and Recreation	2.0%	2.4%	2.4%	2.4%	2.4%	2.4%	2.3%	2.3%	2.3%	2.3%	2.2%
Accommodation and Food Services	6.8%	7.0%	7.0%	7.0%	6.9%	6.9%	6.8%	6.6%	6.4%	6.2%	5.8%
Other Services, Except Public Administration	5.9%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.1%	6.1%	6.0%	5.9%
Federal Civilian Government	1.3%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.3%
Federal Military	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.5%	0.5%
State and Local Government	9.9%	10.3%	10.3%	10.2%	10.2%	10.1%	10.1%	9.9%	9.6%	9.4%	8.9%

Table 4-35. Demographic and Employment Baseline Projections for Economic Impact Area FL-3 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	79,115.35	72,699.32	75,523.98	77,335.32	79,187.57	81,081.56	83,018.17	93,371.74	104,929.66	117,819.11	148,161.00
Farm Employment	0.5%	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.2%
Forestry, Fishing, Related Activities	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Mining	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%
Utilities	0.9%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%
Construction	7.5%	4.4%	4.8%	4.8%	4.7%	4.7%	4.7%	4.5%	4.3%	4.1%	3.8%
Manufacturing	6.8%	6.0%	6.1%	6.0%	5.9%	5.8%	5.8%	5.3%	4.9%	4.5%	3.8%
Wholesale Trade	4.9%	4.8%	4.9%	4.8%	4.8%	4.8%	4.8%	4.7%	4.6%	4.6%	4.4%
Retail Trade	8.3%	7.7%	7.7%	7.6%	7.6%	7.5%	7.5%	7.3%	7.0%	6.8%	6.3%
Transportation and Warehousing	2.3%	2.3%	2.3%	2.3%	2.3%	2.3%	2.3%	2.2%	2.2%	2.1%	2.1%
Information Employment	3.3%	3.1%	3.0%	3.0%	3.0%	3.0%	3.0%	2.9%	2.9%	2.8%	2.7%
Finance and Insurance	8.0%	7.2%	7.2%	7.2%	7.3%	7.3%	7.3%	7.4%	7.5%	7.6%	7.7%
Real Estate / Rental and Lease	2.3%	1.5%	1.5%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.8%	1.9%
Professional and Technical Services	8.1%	9.2%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.1%	9.0%
Management	1.6%	2.4%	2.4%	2.5%	2.5%	2.6%	2.6%	2.8%	3.0%	3.3%	3.7%
Administrative and Waste Services	7.1%	4.8%	4.9%	4.9%	5.0%	5.1%	5.1%	5.4%	5.8%	6.1%	6.9%
Educational Services	0.8%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.3%	1.4%	1.5%	1.7%
Health Care and Social Assistance	12.1%	15.5%	15.4%	15.6%	15.7%	15.9%	16.0%	16.7%	17.4%	18.1%	19.5%
Arts, Entertainment, and Recreation	1.5%	2.0%	2.0%	2.0%	1.9%	1.9%	1.9%	1.9%	1.8%	1.7%	1.6%
Accommodation and Food Services	3.9%	4.2%	4.1%	4.1%	4.0%	4.0%	4.0%	3.8%	3.6%	3.5%	3.2%
Other Services, Except Public Administration	4.0%	4.2%	4.1%	4.1%	4.1%	4.1%	4.1%	4.0%	4.0%	3.9%	3.8%
Federal Civilian Government	2.7%	3.5%	3.4%	3.4%	3.4%	3.4%	3.4%	3.5%	3.5%	3.5%	3.5%
Federal Military	1.2%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.4%	1.4%	1.3%	1.2%
State and Local Government	11.8%	12.8%	12.6%	12.6%	12.5%	12.5%	12.5%	12.3%	12.2%	12.0%	11.6%
Total Personal Income Per Capita (in 2005 dollars)	33,224	31,323	31,639	32,001	32,373	32,754	33,144	35,240	37,593	40,226	46,260
Woods & Poole Economics Wealth Index (U.S. = 100)	79.5	77.2	77.2	77.2	77.1	77.1	77.1	77.0	77.0	77.0	77.0
Persons Per Household (in number of people)	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Mean Household Total Personal Income (in 2005 dollars)	64,512	62,252	63,029	63,502	63,992	64,509	65,058	68,279	72,269	77,062	88,938
Total Number of Households (in thousands)	1,449.40	1,546.55	1,568.95	1,595.36	1,621.62	1,647.70	1,673.53	1,798.54	1,917.25	2,027.90	2,223.65
Income < $10,000 (thousands of households, 2000 dollars)	9.1%	8.7%	8.6%	8.4%	8.3%	8.1%	8.0%	7.2%	6.3%	5.5%	4.1%
Income $10,000 to $19,999	13.8%	13.4%	13.1%	12.9%	12.6%	12.4%	12.1%	11.0%	9.7%	8.4%	6.2%
Income $20,000 to $29,999	14.7%	14.2%	13.9%	13.7%	13.5%	13.2%	12.9%	11.7%	10.3%	8.9%	6.6%
Income $30,000 to $44,999	19.6%	19.5%	19.3%	19.2%	19.0%	18.7%	18.5%	17.1%	15.3%	13.3%	9.9%
Income $45,000 to $59,999	15.1%	15.7%	16.0%	16.3%	16.6%	16.8%	17.1%	18.0%	18.6%	18.4%	15.2%
Income $60,000 to $74,999	9.7%	10.1%	10.3%	10.5%	10.7%	10.9%	11.1%	12.4%	14.2%	16.1%	18.7%
Income $75,000 to $99,999	8.4%	8.7%	8.9%	9.0%	9.2%	9.4%	9.6%	10.7%	12.2%	13.9%	18.7%
Income $100,000 or more	9.4%	9.7%	9.9%	10.1%	10.2%	10.4%	10.7%	11.9%	13.5%	15.4%	20.5%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 12 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-36

Demographic and Employment Baseline Projections for Economic Impact Area FL-4

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Population (in thousands)	5,960.39	6,210.44	6,294.73	6,379.76	6,465.42	6,551.79	6,638.56	7,078.51	7,525.98	7,975.38	8,877.71
Age Under 19 years	24.7%	24.0%	23.9%	23.7%	23.6%	23.6%	23.5%	23.5%	23.2%	23.0%	22.8%
Age 20 to 34	18.5%	18.6%	18.6%	18.7%	18.7%	18.8%	18.8%	18.2%	17.8%	17.5%	17.4%
Age 35 to 49	22.1%	20.8%	20.4%	20.1%	19.7%	19.3%	19.0%	18.3%	18.2%	18.3%	17.2%
Age 50 to 64	17.5%	18.9%	19.1%	19.3%	19.4%	19.6%	19.7%	19.3%	18.3%	16.7%	16.1%
Age 65 and over	17.2%	17.8%	18.0%	18.2%	18.5%	18.8%	19.1%	20.7%	22.5%	24.4%	26.5%
Median Age of Population (in years)	44	45	45	45	45	45	45	46	46	46	46
White Population (in thousands)	46.6%	43.3%	42.7%	42.1%	41.5%	40.9%	40.4%	37.7%	35.3%	32.9%	28.5%
Black Population (in thousands)	16.5%	16.5%	16.6%	16.6%	16.6%	16.7%	16.7%	16.8%	16.9%	17.0%	16.9%
Native American Population (in thousands)	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
Asian and Pacific Islander Population (in thousands)	1.9%	2.1%	2.1%	2.2%	2.2%	2.2%	2.3%	2.5%	2.6%	2.8%	3.2%
Hispanic or Latino Population (in thousands)	34.8%	37.9%	38.5%	39.0%	39.5%	40.0%	40.5%	42.8%	45.0%	47.2%	51.2%
Male Population (in thousands)	48.8%	49.0%	49.1%	49.1%	49.1%	49.1%	49.1%	49.2%	49.2%	49.2%	49.0%
Total Employment (in thousands of jobs)	3,395.35	3,329.05	3,426.96	3,479.99	3,533.68	3,588.03	3,643.04	3,928.30	4,230.99	4,551.70	5,249.44
Farm Employment	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.4%
Forestry, Fishing, Related Activities	0.4%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Mining	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%
Utilities	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Construction	8.0%	5.0%	5.0%	5.0%	5.0%	5.1%	5.1%	5.3%	5.4%	5.6%	5.9%
Manufacturing	3.6%	2.9%	2.9%	2.9%	2.8%	2.8%	2.7%	2.5%	2.4%	2.2%	1.9%
Wholesale Trade	4.5%	4.3%	4.3%	4.2%	4.2%	4.2%	4.1%	3.9%	3.8%	3.6%	3.3%
Retail Trade	11.2%	11.1%	11.1%	11.0%	11.0%	10.9%	10.9%	10.7%	10.5%	10.3%	9.8%
Transportation and Warehousing	3.8%	3.9%	3.9%	3.9%	3.9%	3.8%	3.8%	3.7%	3.7%	3.6%	3.4%
Information Employment	2.0%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.5%	1.4%
Finance and Insurance	5.0%	4.9%	4.9%	4.8%	4.8%	4.8%	4.8%	4.7%	4.5%	4.4%	4.1%
Real Estate / Rental and Lease	6.0%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.0%	6.0%	5.9%
Professional and Technical Services	6.5%	6.8%	6.8%	6.8%	6.8%	6.9%	6.9%	7.0%	7.1%	7.1%	7.3%
Management	0.7%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.9%	0.9%	1.0%
Administrative and Waste Services	9.0%	7.9%	8.0%	8.0%	8.1%	8.2%	8.2%	8.6%	9.0%	9.3%	10.1%
Educational Services	1.8%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.6%	2.7%	2.8%	2.9%
Health Care and Social Assistance	9.1%	11.4%	11.5%	11.6%	11.7%	11.8%	11.8%	12.3%	12.8%	13.2%	14.2%
Arts, Entertainment, and Recreation	2.2%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.4%	2.4%
Accommodation and Food Services	7.2%	7.4%	7.3%	7.3%	7.3%	7.3%	7.2%	7.1%	7.0%	6.8%	6.5%
Other Services, Except Public Administration	7.7%	8.4%	8.4%	8.4%	8.4%	8.4%	8.5%	8.6%	8.7%	8.7%	8.9%
Federal Civilian Government	1.0%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	1.0%	0.9%	0.8%
Federal Military	0.5%	0.5%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%
State and Local Government	9.0%	9.6%	9.6%	9.5%	9.5%	9.5%	9.4%	9.3%	9.1%	9.0%	8.6%

Table 4-36. Demographic and Employment Baseline Projections for Economic Impact Area FL-4 (continued).

	2005	2010	2011	2012	2013	2014	2015	2020	2025	2030	2040
Total Earnings (in millions of 2005 dollars)	146,349.28	133,109.32	138,104.63	141,438.36	144,845.84	148,328.48	151,887.81	170,888.07	192,042.06	215,564.73	270,666.64
Farm Employment	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%
Forestry, Fishing, Related Activities	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Mining	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Utilities	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Construction	9.4%	5.2%	5.6%	5.6%	5.6%	5.5%	5.5%	5.4%	5.3%	5.2%	4.9%
Manufacturing	4.4%	3.6%	3.7%	3.7%	3.6%	3.6%	3.5%	3.3%	3.1%	2.9%	2.5%
Wholesale Trade	6.8%	6.7%	6.9%	6.8%	6.8%	6.7%	6.7%	6.4%	6.2%	5.9%	5.4%
Retail Trade	8.5%	8.4%	8.4%	8.3%	8.3%	8.2%	8.2%	7.9%	7.7%	7.4%	6.9%
Transportation and Warehousing	4.0%	4.0%	3.9%	3.9%	3.9%	3.9%	3.8%	3.7%	3.6%	3.5%	3.2%
Information Employment	3.6%	3.4%	3.4%	3.4%	3.4%	3.3%	3.3%	3.3%	3.2%	3.1%	3.0%
Finance and Insurance	6.9%	6.2%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.1%	6.0%
Real Estate / Rental and Lease	3.7%	2.4%	2.4%	2.4%	2.4%	2.4%	2.5%	2.5%	2.5%	2.6%	2.7%
Professional and Technical Services	8.3%	9.2%	9.1%	9.1%	9.1%	9.2%	9.2%	9.4%	9.5%	9.6%	9.9%
Management	1.3%	1.9%	1.9%	2.0%	2.0%	2.1%	2.1%	2.3%	2.5%	2.7%	3.2%
Administrative and Waste Services	6.2%	4.9%	4.9%	5.0%	5.0%	5.1%	5.1%	5.4%	5.6%	5.9%	6.5%
Educational Services	1.5%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.3%	2.4%	2.5%	2.7%
Health Care and Social Assistance	9.5%	12.2%	12.1%	12.2%	12.3%	12.4%	12.5%	13.0%	13.5%	14.1%	15.1%
Arts, Entertainment, and Recreation	1.6%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.8%	1.7%
Accommodation and Food Services	4.3%	4.6%	4.5%	4.5%	4.5%	4.5%	4.4%	4.3%	4.2%	4.1%	3.9%
Other Services, Except Public Administration	4.2%	4.6%	4.5%	4.5%	4.6%	4.6%	4.6%	4.6%	4.7%	4.7%	4.7%
Federal Civilian Government	2.2%	2.7%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
Federal Military	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%
State and Local Government	11.8%	14.0%	13.8%	13.8%	13.8%	13.8%	13.8%	13.8%	13.7%	13.6%	13.5%
Total Personal Income Per Capita (in 2005 dollars)	37,332	35,529	35,954	36,438	36,933	37,438	37,957	40,740	43,871	47,389	55,589
Woods & Poole Economics Wealth Index (U.S. = 100)	119.1	113.4	113.6	113.8	114.0	114.2	114.5	115.7	117.1	118.5	121.7
Persons Per Household (in number of people)	2.5	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mean Household Total Personal Income (in 2005 dollars)	92,182	86,404	87,645	88,598	89,600	90,651	91,754	98,070	105,688	114,735	137,497
Total Number of Households (in thousands)	2,337.90	2,434.13	2,469.25	2,510.68	2,551.90	2,592.85	2,633.43	2,830.25	3,017.88	3,193.31	3,504.05
Income < $10,000 (thousands of households, 2000 dollars)	9.2%	8.8%	8.7%	8.5%	8.4%	8.2%	8.1%	7.2%	6.4%	5.6%	4.4%
Income $10,000 to $19,999	12.1%	11.7%	11.5%	11.4%	11.2%	11.0%	10.7%	9.6%	8.5%	7.5%	5.8%
Income $20,000 to $29,999	12.6%	12.3%	12.1%	11.9%	11.7%	11.5%	11.2%	10.0%	8.9%	7.9%	6.1%
Income $30,000 to $44,999	17.3%	17.0%	16.8%	16.5%	16.3%	16.0%	15.7%	14.0%	12.4%	11.0%	8.6%
Income $45,000 to $59,999	14.9%	15.3%	15.5%	15.6%	15.8%	15.9%	16.0%	16.2%	15.5%	14.1%	11.0%
Income $60,000 to $74,999	10.6%	11.0%	11.2%	11.4%	11.6%	11.8%	12.0%	13.5%	15.1%	16.3%	15.8%
Income $75,000 to $99,999	10.0%	10.3%	10.5%	10.7%	10.9%	11.1%	11.3%	12.8%	14.4%	16.4%	20.7%
Income $100,000 or more	13.1%	13.5%	13.8%	14.0%	14.3%	14.5%	14.8%	16.7%	18.8%	21.4%	27.6%

Notes: Median age, wealth index, and mean household income is the average of the original Woods & Poole values for the 9 counties in the EIA; income per capita calculated using personal income/total population for the EIA; persons per household calculated using total population/number of households for the EIA.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-37

Baseline Population Projections (in thousands) by Economic Impact Area

Model Year	Calendar Year	AL-1	MS-1	LA-1	LA-2	LA-3	LA-4	TX-1	TX-2	TX-3	FL-1	FL-2	FL-3	FL-4
	2010	725.48	470.61	334.72	587.88	1,126.87	1,267.52	1,771.25	626.33	6,192.43	896.10	657.40	3,624.88	6,210.44
	2011	731.11	474.64	336.53	593.59	1,140.44	1,278.34	1,807.15	634.39	6,299.99	911.70	666.76	3,675.05	6,294.73
1	2012	736.83	478.72	338.39	599.38	1,154.15	1,289.31	1,843.24	642.51	6,408.25	927.40	676.21	3,725.64	6,379.76
2	2013	742.62	482.85	340.27	605.23	1,167.97	1,300.40	1,879.50	650.70	6,517.13	943.19	685.71	3,776.58	6,465.42
3	2014	748.49	487.02	342.20	611.14	1,181.91	1,311.64	1,915.95	658.94	6,626.68	959.08	695.29	3,827.91	6,551.79
4	2015	754.41	491.23	344.15	617.10	1,195.92	1,322.96	1,952.51	667.23	6,736.63	975.02	704.90	3,879.47	6,638.56
5	2016	760.38	495.47	346.12	623.10	1,210.00	1,334.37	1,989.19	675.55	6,847.01	991.02	714.55	3,931.27	6,725.77
6	2017	766.41	499.75	348.12	629.15	1,224.17	1,345.89	2,026.02	683.92	6,957.91	1,007.10	724.26	3,983.37	6,813.50
7	2018	772.47	504.05	350.13	635.22	1,238.39	1,357.45	2,062.92	692.31	7,069.08	1,023.22	734.00	4,035.62	6,901.51
8	2019	778.57	508.38	352.16	641.34	1,252.68	1,369.10	2,099.94	700.73	7,180.66	1,039.39	743.77	4,088.08	6,989.92
9	2020	784.68	512.71	354.20	647.47	1,266.99	1,380.77	2,137.01	709.17	7,292.42	1,055.59	753.56	4,140.64	7,078.51
10	2021	790.89	517.11	356.28	653.68	1,281.45	1,392.61	2,174.35	717.69	7,405.11	1,071.93	763.44	4,193.71	7,168.00
11	2022	797.15	521.54	358.38	659.95	1,296.07	1,404.55	2,212.34	726.31	7,519.54	1,088.51	773.44	4,247.45	7,258.63
12	2023	803.46	526.02	360.48	666.29	1,310.86	1,416.60	2,251.00	735.03	7,635.74	1,105.36	783.58	4,301.88	7,350.40
13	2024	809.82	530.53	362.60	672.68	1,325.83	1,428.75	2,290.33	743.85	7,753.73	1,122.46	793.85	4,357.01	7,443.33
14	2025	815.74	534.70	364.61	678.54	1,339.29	1,439.98	2,323.71	751.75	7,855.87	1,137.26	802.95	4,405.96	7,525.98
15	2026	821.98	539.11	366.70	684.79	1,353.80	1,451.87	2,361.17	760.29	7,968.97	1,153.65	812.85	4,459.20	7,615.86
16	2027	828.26	543.56	368.81	691.09	1,368.46	1,463.87	2,399.24	768.92	8,083.69	1,170.28	822.88	4,513.09	7,706.81
17	2028	834.60	548.05	370.92	697.46	1,383.29	1,475.96	2,437.91	777.65	8,200.07	1,187.15	833.03	4,567.63	7,798.85
18	2029	840.98	552.58	373.05	703.88	1,398.27	1,488.16	2,477.21	786.48	8,318.13	1,204.26	843.31	4,622.84	7,891.99
19	2030	846.94	556.77	375.07	709.79	1,411.83	1,499.47	2,511.01	794.43	8,421.37	1,219.22	852.48	4,672.19	7,975.38
20	2031	853.17	561.19	377.17	716.05	1,426.34	1,511.37	2,548.50	802.95	8,534.58	1,235.62	862.38	4,725.46	8,065.35
21	2032	859.46	565.63	379.27	722.36	1,440.99	1,523.36	2,586.55	811.57	8,649.31	1,252.25	872.41	4,779.34	8,156.35
22	2033	865.79	570.12	381.39	728.73	1,455.80	1,535.45	2,625.17	820.28	8,765.59	1,269.10	882.54	4,833.83	8,248.36
23	2034	872.17	574.64	383.51	735.16	1,470.76	1,547.64	2,664.37	829.09	8,883.43	1,286.17	892.80	4,888.94	8,341.42
24	2035	878.13	578.84	385.53	741.09	1,484.37	1,558.97	2,698.47	837.06	8,987.43	1,301.24	902.01	4,938.54	8,425.26
25	2036	884.41	583.28	387.64	747.40	1,498.95	1,570.96	2,736.13	845.63	9,101.21	1,317.72	911.96	4,992.08	8,515.75
26	2037	890.74	587.76	389.77	753.76	1,513.68	1,583.03	2,774.31	854.28	9,216.42	1,334.42	922.03	5,046.20	8,607.21
27	2038	897.11	592.27	391.90	760.17	1,528.55	1,595.20	2,813.03	863.02	9,333.09	1,351.32	932.20	5,100.91	8,699.66
28	2039	903.53	596.82	394.04	766.64	1,543.57	1,607.46	2,852.29	871.85	9,451.24	1,368.44	942.49	5,156.22	8,793.09
29	2040	909.54	601.05	396.08	772.62	1,557.29	1,618.89	2,886.77	879.89	9,556.30	1,383.66	951.77	5,206.25	8,877.71
30	2041	916.04	605.67	398.25	779.20	1,572.59	1,631.33	2,927.06	888.89	9,677.28	1,401.19	962.28	5,262.70	8,973.06
31	2042	922.60	610.31	400.43	785.83	1,588.03	1,643.87	2,967.91	897.99	9,799.78	1,418.94	972.89	5,319.75	9,069.43
32	2043	929.20	615.00	402.62	792.52	1,603.64	1,656.50	3,009.33	907.18	9,923.84	1,436.92	983.63	5,377.43	9,166.84
33	2044	935.84	619.72	404.83	799.26	1,619.39	1,669.23	3,051.33	916.46	10,049.47	1,455.12	994.48	5,435.73	9,265.29
34	2045	942.54	624.47	407.04	806.06	1,635.30	1,682.06	3,093.91	925.84	10,176.68	1,473.56	1,005.45	5,494.66	9,364.80
35	2046	949.28	629.27	409.27	812.92	1,651.37	1,694.99	3,137.09	935.31	10,305.51	1,492.22	1,016.55	5,554.23	9,465.38
36	2047	956.07	634.09	411.51	819.84	1,667.59	1,708.02	3,180.87	944.88	10,435.97	1,511.13	1,027.76	5,614.45	9,567.04
37	2048	962.91	638.96	413.76	826.82	1,683.97	1,721.15	3,225.27	954.55	10,568.08	1,530.27	1,039.10	5,675.32	9,669.80
38	2049	969.80	643.86	416.03	833.86	1,700.52	1,734.37	3,270.28	964.32	10,701.87	1,549.66	1,050.57	5,736.85	9,773.65
39	2050	976.73	648.81	418.30	840.95	1,717.22	1,747.70	3,315.92	974.19	10,837.34	1,569.29	1,062.16	5,799.05	9,878.62
40	2051	983.72	653.78	420.59	848.11	1,734.09	1,761.14	3,362.20	984.16	10,974.54	1,589.17	1,073.88	5,861.92	9,984.72

Notes: Actual Woods & Poole data for 2010 through 2020, 2025, 2030, 2035, and 2040. Missing estimates through 2040 calculated using average annual growth rate for the 5-year period; projections after 2040 calculated using the average annual growth rate from 2035 to 2040.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-38

Baseline Employment Projections (in Thousands) by Coastal Subarea

Model Year	Calendar Year	AL-1	MS-1	LA-1	LA-2	LA-3	LA-4	TX-1	TX-2	TX-3	FL-1	FL-2	FL-3	FL-4
	2010	353.63	243.91	177.73	321.93	663.02	728.32	840.00	309.97	3,596.00	489.82	330.09	1,868.77	3,329.05
	2011	362.59	249.36	182.05	330.21	680.63	745.53	864.86	317.96	3,700.61	504.24	338.56	1,922.79	3,426.96
1	2012	366.69	251.56	183.91	334.03	689.17	752.64	878.23	321.85	3,758.99	512.13	342.74	1,951.29	3,479.99
2	2013	370.81	253.76	185.81	337.89	697.80	759.77	891.81	325.78	3,818.15	520.13	346.98	1,980.12	3,533.68
3	2014	374.97	255.98	187.70	341.78	706.51	766.93	905.55	329.76	3,878.09	528.26	351.28	2,009.31	3,588.03
4	2015	379.15	258.22	189.62	345.70	715.33	774.11	919.48	333.78	3,938.83	536.52	355.62	2,038.85	3,643.04
5	2016	383.37	260.47	191.54	349.65	724.23	781.30	933.58	337.82	4,000.39	544.90	360.02	2,068.76	3,698.74
6	2017	387.62	262.73	193.50	353.63	733.24	788.52	947.87	341.92	4,062.77	553.43	364.46	2,099.03	3,755.10
7	2018	391.90	265.01	195.46	357.65	742.34	795.74	962.34	346.07	4,125.95	562.07	368.98	2,129.66	3,812.15
8	2019	396.21	267.30	197.44	361.69	751.53	802.98	977.00	350.24	4,189.99	570.86	373.54	2,160.65	3,869.88
9	2020	400.55	269.62	199.43	365.76	760.83	810.24	991.85	354.48	4,254.86	579.78	378.16	2,192.00	3,928.30
10	2021	404.99	271.97	201.47	369.93	770.43	817.53	1,007.28	358.83	4,322.32	589.12	382.95	2,224.49	3,988.84
11	2022	409.48	274.34	203.54	374.15	780.14	824.89	1,022.95	363.24	4,390.84	598.61	387.81	2,257.47	4,050.31
12	2023	414.02	276.74	205.62	378.41	789.98	832.32	1,038.87	367.71	4,460.45	608.25	392.73	2,290.93	4,112.73
13	2024	418.61	279.15	207.73	382.73	799.95	839.81	1,055.03	372.22	4,531.17	618.06	397.71	2,324.89	4,176.11
14	2025	422.75	281.38	209.65	386.61	808.81	846.71	1,069.01	376.26	4,592.14	626.48	402.13	2,354.46	4,230.99
15	2026	427.35	283.81	211.77	390.93	818.92	854.06	1,085.44	380.83	4,664.06	636.56	407.23	2,388.90	4,295.13
16	2027	431.99	286.26	213.92	395.30	829.16	861.46	1,102.12	385.46	4,737.10	646.80	412.39	2,423.83	4,360.25
17	2028	436.69	288.73	216.09	399.71	839.52	868.93	1,119.07	390.14	4,811.29	657.21	417.62	2,459.28	4,426.35
18	2029	441.43	291.22	218.28	404.18	850.02	876.47	1,136.27	394.88	4,886.64	667.78	422.92	2,495.24	4,493.45
19	2030	445.72	293.52	220.27	408.21	859.36	883.43	1,151.17	399.12	4,951.73	676.88	427.62	2,526.62	4,551.70
20	2031	450.47	296.02	222.48	412.68	870.01	890.79	1,168.65	403.92	5,028.34	687.75	433.04	2,563.07	4,619.55
21	2032	455.27	298.55	224.71	417.21	880.78	898.22	1,186.39	408.78	5,106.13	698.79	438.53	2,600.03	4,688.42
22	2033	460.12	301.09	226.97	421.78	891.69	905.70	1,204.41	413.70	5,185.13	710.01	444.09	2,637.53	4,758.32
23	2034	465.02	303.66	229.25	426.41	902.73	913.25	1,222.69	418.67	5,265.35	721.41	449.72	2,675.58	4,829.26
24	2035	469.47	306.03	231.32	430.59	912.57	920.25	1,238.56	423.13	5,334.78	731.22	454.72	2,708.83	4,890.99
25	2036	474.37	308.61	233.62	435.21	923.76	927.61	1,257.14	428.15	5,416.31	742.93	460.49	2,747.36	4,962.68
26	2037	479.32	311.21	235.94	439.89	935.09	935.02	1,275.99	433.24	5,499.10	754.83	466.32	2,786.44	5,035.42
27	2038	484.33	313.83	238.28	444.61	946.56	942.50	1,295.13	438.38	5,583.14	766.92	472.24	2,826.08	5,109.23
28	2039	489.39	316.47	240.64	449.38	958.16	950.04	1,314.56	443.59	5,668.48	779.21	478.22	2,866.28	5,184.12
29	2040	493.98	318.92	242.80	453.71	968.53	957.04	1,331.45	448.26	5,742.46	789.79	483.55	2,901.49	5,249.44
30	2041	499.14	321.61	245.21	458.58	980.40	964.70	1,351.41	453.58	5,830.23	802.44	489.67	2,942.76	5,326.39
31	2042	504.35	324.31	247.64	463.51	992.42	972.41	1,371.68	458.97	5,919.33	815.29	495.88	2,984.61	5,404.46
32	2043	509.62	327.05	250.10	468.48	1,004.59	980.19	1,392.26	464.42	6,009.81	828.36	502.17	3,027.07	5,483.67
33	2044	514.94	329.80	252.58	473.52	1,016.91	988.02	1,413.14	469.94	6,101.66	841.63	508.53	3,070.12	5,564.05
34	2045	520.32	332.58	255.09	478.60	1,029.38	995.93	1,434.33	475.52	6,194.92	855.11	514.98	3,113.79	5,645.61
35	2046	525.76	335.38	257.62	483.74	1,042.00	1,003.89	1,455.85	481.17	6,289.60	868.81	521.51	3,158.08	5,728.36
36	2047	531.25	338.20	260.17	488.94	1,054.78	1,011.92	1,477.68	486.88	6,385.73	882.72	528.12	3,203.00	5,812.32
37	2048	536.80	341.05	262.75	494.19	1,067.71	1,020.01	1,499.84	492.66	6,483.33	896.87	534.81	3,248.56	5,897.52
38	2049	542.40	343.92	265.36	499.49	1,080.81	1,028.17	1,522.34	498.52	6,582.42	911.23	541.59	3,294.77	5,983.96
39	2050	548.07	346.82	267.99	504.86	1,094.06	1,036.39	1,545.17	504.44	6,683.02	925.83	548.46	3,341.64	6,071.67
40	2051	553.79	349.74	270.65	510.28	1,107.48	1,044.68	1,568.35	510.43	6,785.16	940.66	555.41	3,389.17	6,160.67

Notes: Actual Woods & Poole data for 2010 through 2020, 2025, 2030, 2035, and 2040. Missing estimates through 2040 calculated using average annual growth rate for the 5 year period; projections after 2040 calculated using the average annual growth rate from 2035 to 2040.

Source: Woods & Poole Economics, Inc., 2010.

Table 4-39

Liquid Waste Collected from the *Deepwater Horizon* Event

Landfill Name	Percentage
Newpark Environmental Services—Fourchon Site Code 2913	29.67%
River Birch Industries Landfill	17.60%
Apex Environmental Services	17.44%
Liquid Environmental Solutions	13.07%
Tidewater Landfill LLC (Environmental Operations) Coast Guard Road Sanitary Landfill	11.08%
Newpark Environmental Mud Facility—Venice	11.08%
MBO LLC (Lacassine Oilfield Services)	3.20%
Newpark Environmental Services—Morgan City Site Code 5102	2.84%
Chemical Waste Management	1.04%
Aaron Oil	0.89%
Waste Water	0.83%
Intergulf	0.58%
Cliff Berry, Inc.—Tampa/ Miami	0.55%
Clearview Landfill	0.46%
Newpark Environmental Intercoastal City	0.27%
Vacco Marine	0.16%
Oil Recovery Company	0.08%
Vacco Marine/River Birch	0.03%
City of Tampa Treatment Plant	0.01%
Bealine	0.00%
SWS	0.00%
Gulf Coast Water Authority	0.00%
M.A. Norden Company	0.00%
WH Chastang Landfill	0.00%
Geocycle/Holcim	0.00%
Sunbelt Crushing	0.00%
Baldwin County Magnolia Landfill	0.00%
Tarpon Recycling	0.00%
Covanta-Huntsville	0.00%
WM Springhill Regional Landfill	0.00%
Fort Walton Transfer	0.00%
Gulf West Landfill (Texas)	0.00%
Allied Waste/BFI Colonial Landfill	0.00%
Jefferson Parish Waste Management	0.00%
Allied Waste Jefferson Davis Parish	0.00%
Allied Waste Recycling Center	0.00%
Newpark Environmental Services—Cameron Site Code 1205	0.00%
Advanced Disposal Services	0.00%
WM Pecan Grove	0.00%
Coastal Plains—Waste Management	0.00%

Sources: British Petroleum, 2011a and 2011b.

Table 4-40

Solid Waste Collected from the *Deepwater Horizon* Event

Landfill Name	Percentage
WM Springhill Regional Landfill	26.11%
Allied Waste/BFI Colonial Landfill	25.12%
Baldwin County Magnolia Landfill	11.31%
Clearview Landfill	8.66%
Newpark Environmental Services—Fourchon Site Code 2913	7.99%
River Birch Industries Landfill	7.70%
WH Chastang Landfill	6.81%
Jefferson Parish Waste Management	6.56%
Newpark Environmental Services—Cameron Site Code 1205	4.60%
WM Pecan Grove	3.82%
Covanta-Huntsville	0.78%
Tidewater Landfill LLC (Environmental Operations) Coast Guard Road Sanitary Landfill	0.50%
Sunbelt Crushing	0.34%
M.A. Norden Company	0.17%
Tarpon Recycling	0.07%
Coastal Plains—Waste Management	0.06%
Allied Waste Recycling Center	0.03%
Gulf West Landfill (Texas)	0.03%
Fort Walton Transfer	0.02%
Advanced Disposal Services	0.00%
Intergulf	0.00%
Aaron Oil	0.00%
Geocycle/Holcim	0.00%
Apex Environmental Services	0.00%
Liquid Environmental Solutions	0.00%
Chemical Waste Management	0.00%
Oil Recovery Company	0.00%
City of Tampa Treatment Plant	0.00%
Cliff Berry, Inc.—Tampa/ Miami	0.00%
Vacco Marine	0.00%
Vacco Marine/River Birch	0.00%
Gulf Coast Water Authority	0.00%
Waste Water	0.00%
Allied Waste Jefferson Davis Parish	0.00%
Newpark Environmental Mud Facility—Venice	0.00%
Newpark Environmental Services—Morgan City Site Code 5102	0.00%
Newpark Environmental Intercoastal City	0.00%
MBO LLC (Lacassine Oilfield Services)	0.00%
Bealine	0.00%
SWS	0.00%

Sources: British Petroleum, 2011a and 2011b.

Table 4-41

Deepwater Horizon Waste Destination Communities

Landfill Name and Location	Percent Minority living within 1-Mile Radius of Site	Total Population living within 1-Mile Radius of Site (2000 Census)	Percentage of Total DWH Liquid Waste Collected	Percentage of Total DWH Solid Waste Collected
Liquid Environmental Solutions, Mobile, AL	95.80%	4,257	13.17%	0.00%
Oil Recovery Company, Mobile, AL	93.90%	3,238	0.08%	0.00%
Cliff Berry, Inc.—Miami, FL	92.80%	24,768	>0.58%	0.00%
River Birch Industries Landfill Avondale, LA	92.20%	167	16.99%	8.67%
Jefferson Parish Waste Management, Avondale, LA	91.40%	120	0.00%	0.02%
Sunbelt Crushing, Mobile, AL	76.80%	3,173	0.00%	0.29%
Chemical Waste Management, Emelle, AL	75.20%	33	1.02%	0.00%
WM Springhill Regional Landfill, Campbelton, FL	74.30%	109	0.00%	23.67%
Allied Waste/BFI Colonial Landfill, Sorrento, LA	74.10%	153	0.00%	21.98%
Allied Waste Recycling Center, Metairie, LA	63.50%	14,420	0.00%	0.06%
WH Chastang Landfill, Mount Vernon, AL	62.50%	123	0.00%	8.93%
Clearview Landfill Lake, MS	50.90%	55	0.44%	14.92%
Cliff Berry, Inc.—Tampa, FL	50.50%	1,817	>0.58%	0.00%
Apex Environmental Services, Theodore, AL	50.40%	383	17.44%	0.00%
Newpark Environmental Services Site Code 5102 Morgan City, LA	35.90%	4,237	2.74%	0.00%
Landfill Name and Location	**Percent Below Poverty Living within a 1-Mile Radius of Site**	**Total Population Living within a 1-Mile Radius of Site (2000 Census)**	**Percentage of Total DWH Event Liquid Waste Collected**	**Percentage of Total DWH Event Solid Waste Collected**
Liquid Environmental Solutions, Mobile, AL	63.30%	4,257	13.17%	0.00%
Newpark Environmental Mud Facility—Venice, LA	50.00%	2	10.90%	0.00%
Oil Recovery Company, Mobile, AL	41.70%	3,238	0.08%	0.00%
Chemical Waste Management, Emelle, AL	36.40%	33	1.02%	0.00%
Newpark Environmental Services Site Code 2913, Fourchon, LA	33.30%	3	30.14%	0.00%
Vacco Marine, Houma, LA	29.20%	525	0.16%	0.00%
River Birch Industries Landfill, Avondale, LA	28.10%	167	16.99%	8.67%
Jefferson Parish Waste Management, Avondale, LA	26.70%	120	0.00%	0.02%
Apex Environmental Services, Theodore, AL	26.20%	383	17.44%	0.00%
Allied Waste/BFI Colonial Landfill, Sorrento, LA	25.00%	153	0.00%	21.98%
WM Pecan Grove, Pass Christian, MS	14.40%	290	0.00%	3.28%
Baldwin County Magnolia Landfill, AL	13.70%	446	0.00%	11.18%
MBO LLC (Lacassine Oilfield Services)	12.90%	85	3.82%	0.00%
Coast Guard Rd Sanitary Landfill	0.00%	0	0.00%	8.05%

Sources: British Petroleum, 2011 and 2011b.

Table 4-42

Gulf Coast Claims Facility—*Deepwater Horizon* Claimant Data by State

Alabama Claimant Status	No. of Claimants
TOTAL GCCF Claimants to Date *(Claimants may have one or more Claim Type)*	66,129
1. Claimants Paid and Approved for Payment	26,815
2. Claimants Requiring Additional Information or Documentation (Claimants providing no documentation: 7,503)	10,913
3. Claimants Referred to Government, Moratorium and Real Estate Funds	1
4. Denied Claimants	22,080
5. Claimants Under Review (Emergency Advance Payment)	4,561
6. Claimants Under Review (for Final Claim Only)	1,759

State	Claims for Emergency or Final Payment *(includes Individual and Business)*	Claims Submitted	Number of Claims Paid	Amount Paid
Alabama	1. Removal and Cleanup Costs	394	0	$0
	2. Real or Personal Property	1,201	35	$364,463
	3. Lost Earnings or Profits	65,655	26,380	$426,205,265
	4. Loss of Subsistence Use of Natural Resources	4,119	3	$9,000
	5. Physical Injury/Death	745	5	$1,300
Alabama Total	Total to Date	72,114	55,166	$426,580,028

Florida Claimant Status	No. of Claimants
TOTAL GCCF Claimants to Date *(Claimants may have one or more Claim Type)*	151,760
1. Claimants Paid and Approved for Payment	63,578
2. Claimants Requiring Additional Information or Documentation (Claimants providing no documentation: 7,503)	20,557
3. Claimants Referred to Government, Moratorium and Real Estate Funds	0
4. Denied Claimants	50,858
5. Claimants Under Review (Emergency Advance Payment)	12,093
6. Claimants Under Review (for Final Claim Only)	4,674

State	Claims for Emergency or Final Payment *(includes Individual and Business)*	Claims Submitted	Number of Claims Paid	Amount Paid
Florida	1. Removal and Cleanup Costs	573	0	$0
	2. Real or Personal Property	2,319	23	$71,400
	3. Lost Earnings or Profits	153,118	62,362	$848,846,576
	4. Loss of Subsistence Use of Natural Resources	2,473	0	$0
	5. Physical Injury/Death	552	0	$0
Florida Total	Total to Date	159,035	62,385	$848,917,976

Table 4-42. Gulf Coast Claims Facility—*Deepwater Horizon* Claimant Data by State (continued).

Louisiana Claimant Status	No. of Claimants
TOTAL GCCF Claimants to Date *(Claimants may have one or more Claim Type)*	187,476
1. Claimants Paid and Approved for Payment	56,308
2. Claimants Requiring Additional Information or Documentation (Claimants providing no documentation: 7,503)	38,906
3. Claimants Referred to Government, Moratorium and Real Estate Funds	8
4. Denied Claimants	75,495
5. Claimants Under Review (Emergency Advance Payment)	12,136
6. Claimants Under Review (for Final Claim Only)	4,623

State	Claims for Emergency or Final Payment *(includes Individual and Business)*	Claims Submitted	Number of Claims Paid	Amount Paid
Louisiana	1. Removal and Cleanup Costs	1,155	0	$0
	2. Real or Personal Property	2,876	39	$421,400
	3. Lost Earnings or Profits	173,632	55,120	$817,551,315
	4. Loss of Subsistence Use of Natural Resources	16,553	1	$3,000
	5. Physical Injury/Death	6,043	6	$7,800
Louisiana Total	Total to Date	200,259	55,166	$817,983,515

Mississippi Claimant Status	No. of Claimants
TOTAL GCCF Claimants to Date *(Claimants may have one or more Claim Type)*	49,879
1. Claimants Paid and Approved for Payment	14,218
2. Claimants Requiring Additional Information or Documentation (Claimants providing no documentation: 7,503)	6,963
3. Claimants Referred to Government, Moratorium and Real Estate Funds	5
4. Denied Claimants	24,143
5. Claimants Under Review (Emergency Advance Payment)	3,155
6. Claimants Under Review (for Final Claim Only)	1,395

State	Claims for Emergency or Final Payment *(includes Individual and Business)*	Claims Submitted	Number of Claims Paid	Amount Paid
Mississippi	1. Removal and Cleanup Costs	282	0	$0
	2. Real or Personal Property	1,040	13	$63,500
	3. Lost Earnings or Profits	44,793	13,978	$202,514,200
	4. Loss of Subsistence Use of Natural Resources	6,299	1	$1,000
	5. Physical Injury/Death	844	4	$4,737
Mississippi Total	Total to Date	53,258	13,996	$202,583,437

Table 4-42. Gulf Coast Claims Facility—Deepwater Horizon Claimant Data by State (continued).

Texas Claimant Status	No. of Claimants
TOTAL GCCF Claimants to Date *(Claimants may have one or more Claim Type)*	9,583
1. Claimants Paid and Approved for Payment	2,657
2. Claimants Requiring Additional Information or Documentation (Claimants providing no documentation: 7,503)	587
3. Claimants Referred to Government, Moratorium and Real Estate Funds	0
4. Denied Claimants	5,412
5. Claimants Under Review (Emergency Advance Payment)	537
6. Claimants Under Review (for Final Claim Only)	390

State	Claims for Emergency or Final Payment *(includes Individual and Business)*	Claims Submitted	Number of Claims Paid	Amount Paid
Texas	1. Removal and Cleanup Costs	79	0	$0
	2. Real or Personal Property	167	4	$50,000
	3. Lost Earnings or Profits	9,371	2,618	$81,394,000
	4. Loss of Subsistence Use of Natural Resources	301	0	$0
	5. Physical Injury/Death	277	1	$100
Texas Total	Total to Date	10,195	2,623	$81,444,100

Sources: Gulf Coast Claims Facility, 2010 and 2011.

Table 5-1

Scoping Comments

Name and Affiliation	Concerns
Defenders of Wildlife Washington, DC	• Ensure the reanalysis of baseline conditions is woven into the Agency's decision-making process. • The Supplemental EIS should include impacts to threatened and endangered species, target and nontarget fish species, water quality, seafloor conditions, and any other natural resources affected by the *Deepwater Horizon* spill. • The BOEMRE must closely examine the types of basic information about the Gulf marine environment that were not analyzed prior to the spill. • The reassessment of risk for future oil spills has two primary components. First, BOEMRE must reexamine the risk of oil spills in general. Second, BOEMRE must reexamine the risk of oil spills in the particular locations and conditions at issue in a particular NEPA analysis. • As BOEMRE examines the risk of future oil spills occurring, BOEMRE also must look closely at the likely impact of such spills. • The BOEMRE must ensure that its use of categorical exclusions and environmental assessments that tier to the Multisale EIS are on solid footing by taking a precautionary approach that reexamines the environmental impacts of a range of oil and gas activities that have not been analyzed adequately, or in some cases analyzed at all. • In examining ways to maximize avoidance and minimize impacts to environmental resources, BOEMRE should begin with analyzing additional measures to address safety and well control issues for both deep and shallow-water operations. • The Supplemental EIS also should examine options for improving offshore inspections and safety procedures, enforcing stronger cementing and well control protocols, and requiring improvements in the reliability factor of blowout prevention technology in any water depth. • Defenders of Wildlife further recommends that BOEMRE enact a hiatus in future permits and approvals for floating offshore storage and processing vessels due to the spill threat posed by these facilities and the demonstrated lack of effective response capabilities for large oil releases evidenced during the *Deepwater Horizon* event, and we request that this limitation on future permitting be analyzed in the Supplemental EIS. • In addition to the regulatory suggestions listed above, the Supplemental EIS should also assess the impact of requiring the following measures to increase worker safety, protect sensitive ecosystems and marine and intertidal habitats, and ensure a more adequate, rapid response to future OCS disasters: (1) research, development, and implementation of a new type of fail-safe backup valve, shut-in device that would reliably preclude loss of well control in the event of the failure of the blowout preventer in any water depth; measures beyond a future requirement of a second blind shear ram will likely be necessary; (2) predeployment of a rig capable of drilling a relief well at the appropriate water depth in a location within a certain reasonable response time of every drilling site; (3) strict requirements that oil spill contingency plans be certified by the U.S. Government as capable of immediate response in the event of a "worst case" well blowout, riser break, damaged floating storage vessel, tankship spill, or other cause of a major hydrocarbon release into the marine environment; (4) research and development of new types of biodegradable dispersants, their comprehensive testing and certification by USEPA for use in mass quantities under predefined

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
Defenders of Wildlife Washington, DC	appropriate conditions, their manufacture in commercial quantities, and their predeployment at locations of possible future need; (5) engineering and development of large ship-scaled oil skimmers for use in realistic wind, wave, and ocean current conditions, to be certified by the U.S. Coast Guard and built and operated by the petroleum industry; (6) immediate development and manufacture of more effective oil spill containment technologies and sorbent booms, and their predeployment in storage facilities in geographic areas of likely future need; (7) required testing of spill response technology in real world conditions and mandatory certification as to the measurable response impact of response equipment and plans; (8) a minimum requirement for response capacity onsite or within reasonable distance such that operators have capacity to recover a certain minimum percentage of oil spilled; and (9) bonding requirements sufficient to cover the cost of response and cleanup in the event of a blowout or other spill are necessary. • The No Action alternative of canceling the remaining lease sales should receive robust consideration in order to guarantee maximum protection for the resources that have been damaged by the *Deepwater Horizon* event. • The Defenders of Wildlife further reiterate that no activities in reliance on the previous inadequate Gulf Multisale EIS should move forward until the Supplemental EIS is complete, including all analyses that tier to the previous EIS to justify use of an environmental assessment or categorical exclusion. • The Supplemental EIS should also strongly consider exclusion of sensitive areas and possible recommendations for Gulf marine protected areas.
Center for Biological Diversity San Francisco, CA	• In determining the scope of the environmental impacts of OCS drilling in the GOM, BOEMRE should take into account the fact that many of the species move in and throughout the GOM. • It should also take into account all aspects of drilling including spills—both large and small, seismic activities—both noise impacts and vessel strikes, impacts to fisheries, tourism, and other industries that rely on the health of the GOM. • It is unclear at this time, and may be for some time, the entire impact of the spill on the flora and fauna of the GOM; therefore, BOEMRE should employ precautionary principles in its estimates of the harm as well as its assumptions about future spills. • The BOEMRE must also take into account the already degraded status of the Gulf of Mexico in its assessment of the environmental baseline, as well as the effect of these persistent stressors. • The BOEMRE should include detailed assessments of (1) areas of high seismic risk or seismicity, relatively untested deep water, or remote areas; or (2) activities within the boundary of a proposed or established marine sanctuary, and/or within or near the boundary of a proposed or established wildlife refuge or areas of high biological sensitivity; or (3) activities in areas of hazardous natural bottom conditions; or (4) utilizing new or unusual technology. • The BOEMRE should analyze and review areas and activities in the GOM OCS program that (a) have significant impacts on public health or safety; (b) have significant impacts on such natural resources and unique geographic characteristics as historic or cultural resources; park, recreation, or refuge lands; wilderness areas; wetlands (Executive Order 11990); floodplains (Executive Order 11988); national monuments; migratory birds; and other ecologically significant or critical areas;

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
Center for Biological Diversity San Francisco, CA	(c) have highly controversial environmental effects or involve unresolved conflicts concerning alternative uses of available resources [NEPA Section 102(2)(E)]; (d) have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks; . . . . (h) have significant impacts on species listed, or proposed to be listed, on the List of Endangered or Threatened Species or have significant impacts on designated Critical Habitat for these species; (i) violate a Federal law, or a State, local, or tribal law or requirement imposed for the protection of the environment. • The BOEMRE should also address the following significant issues in its Supplemental EIS: (1) environmental impacts or worst-case scenario oil spills and cumulative oil spills, including response activities and the use of dispersants; (2) the direct, indirect, and cumulative climate change impacts of the action, including the greenhouse gas emissions from the produced oil and gas, and the influence of those climate change impacts on the affected environment; (3) the impacts of the action on special status species such as those protected under the Endangered Species Act and Marine Mammal Protection Act and sensitive habitat areas, including but not limited to critical habitat, essential fish habitat, marine protected areas; (4) a reasonable range of alternatives that would avoid or minimize environmental impacts; (5) broader cumulative impacts analysis which take into consideration the incremental impacts of the action when considered in conjunction with past, present, and reasonably foreseeable future actions in the Gulf; (6) at lease sale and exploration stages, each EIS should contain site-specific analyses, smaller in scale than a typical multisale EIS, though not so narrowly focused as to result in impermissible segmentation of the project; (7) at exploration and drilling stages, specific focus on time and place of activity, keeping in mind seasonal shifts in migratory patterns and habitat composition.
Chevron North America Exploration and Production Company Houston, TX	• The Supplemental EIS should be confined to truly new information and focus on impacts of accidental events and to a lesser extent, cumulative impacts. • The BOEMRE must heed its own finding that a catastrophic spill remains a very low probability. • The planned Supplemental EIS must proceed with the supplemental analyses based upon information available at a certain date and cannot rely on speculative information and not await a series of new GOM studies. • When there are gaps in data and knowledge, BOEMRE must identify the information that is not known in the Supplemental EIS. • The BOEMRE must carefully review all new information and ensure its reliability before inclusion in the Supplemental EIS. • The BOEMRE must consider recent, significant improvements in safety and response capacity in the Supplemental EIS. • Chevron encourages BOEMRE to consider a reasonable range of clearly defined proposed alternatives and each alternative should be concise with no ambiguity. • Future NEPA analysis should tier to this Supplemental EIS. • The BOEMRE must review any suggestions for new and additional mitigation measures very carefully and have sufficient information to support their adoption. • There is no evidence that certain activities at a particular water depth are inherently more dangerous than others.

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
Dean Peeler Alabama Petroleum Council (APC) Mobile, AL	• It is prudent to update the baseline conditions and potential environmental effects of oil and natural gas leasing. • The BOEMRE should use any currently new information that helps evaluate the defined impacts of the lease sales. • Proposed Lease Sales 216, 218, and 222 should be held with no reduction in the acreage traditionally offered in areawide lease sales. • The Supplemental EIS development should complement other environmental analyses by BOEMRE on the 2012-2017 5-Year Program.
Andy Radford American Petroleum Institute (API)	• Lease Sales 216, 218, and 222 should be held with no reduction in the acreage traditionally offered in areawide lease sales. • The scope of the Supplemental EIS should be focused specifically on new information that is readily available during the drafting of the Supplemental EIS and should limit the Supplemental EIS to an analysis of this new information as it exists at this time. • The BOEMRE must consider the extensive safety improvements implemented since the *Deepwater Horizon* event and consider the possibility of a catastrophic oil spill remains a very low probability. • The implementation of new drilling and environmental safeguards by industry since the *Deepwater Horizon* event should be considered and analyzed in the Supplemental EIS. • The possibility of another catastrophic spill will be reduced even further since implementation of the extensive safety improvements. • The Supplemental EIS should be designed specifically to be used as a reference for tiering in the future.
Marine Mammal Commission Bethesda, MD	• The BOEMRE should develop a set of standards for baseline information needed to assess the effects of oil and gas operations on marine mammals and their environment, initiate research on these topics prior to the resumption of lease sales in the Gulf of Mexico, and consider ways to improve oil-spill prevention and response capabilities.
U.S. Fish and Wildlife Service Lafayette, LA	• The Supplemental EIS should evaluate direct, indirect, and cumulative oil spill impacts from MC 252 to wetlands, migratory birds, endangered and threatened species, and designated critical habitat, as well as any impacts to those FWS trust resources from potential future spills. • Any possible correlations of the MC 252 spill and potential future spills to climate change should also be discussed. • The Supplemental EIS should include an assessment of potential direct, indirect, and cumulative impacts (including global climate change) to FWS trust resources from oil and gas industry exploration, development and response activities. • The FWS requests that BOEMRE discuss the relative risk of exploration and production wells leaking oil on the continental shelf versus those located on the continental slope and deepwater Gulf of Mexico. The BOEMRE should revise spill probabilities and model different sized spills, including catastrophic or multiday spills for the Gulf of Mexico for sources of spills in offshore and nearshore environments. • Any new safety regulations or revised permit review processes should be evaluated in the proposed Supplemental EIS for their impact to FWS trust resources. Changes to spill contingency planning, spill response, and restoration actions should also be described and their effects on FWS trust resources assessed.

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
International Association of Geophysical Contractors (IAGC) Houston, TX	• Any analysis of alternatives should recognize and take into account the improved regulatory management, oversight, and enforcement enacted since the blowout of the Macondo well and the resulting oil spill. • The BOEMRE should analyze an alternative that includes the holding of all remaining scheduled lease sales for the entire Western and Central Planning Areas. • The IAGC believes that there should be no discrimination between areas within the Western and Central Planning Areas in regard to geophysical, leasing, drilling, and production activities based upon popular political goals or environmental opinions that cannot be substantiated. • The IAGC strongly recommends that the final Supplemental EIS clearly provide for and facilitate new geophysical data acquisition and subsequent analysis of the hydrocarbon production of the Western and Central Planning Areas. • In developing the Supplemental EIS, BOEMRE should only rely on the best available scientific information and knowledge. • The IAGC also encourages BOEMRE to consider the environmental and socioeconomic information gathered and analyzed, and the conclusions made as part of this process to be utilized in the Supplemental EIS to be developed for the next 5-Year OCS Program.
Stone Energy Lafayette, LA	• Stone Energy recommends that BOEMRE incorporate consideration of all new regulations and requirements put in place post-Macondo.
Consumer Energy Alliance Houston, TX	• The BOEMRE should proceed with the Supplemental EIS in an expedited and efficient manner, and consider thoroughly the socioeconomic impacts of oil and gas development on coastal communities.
National Oceanic and Atmospheric Administration, National Marine Fisheries Service St. Petersburg, FL	• The BOEMRE should consider the understatement of frequency and magnitude of oil spills, understatement of potential environmental impacts of oil spills, the need to better evaluate the potential adverse impacts that a spill could have on the seafood industry and markets, the need to better evaluate modeling of spills, and the need to address cumulative impacts on wetlands. • The Supplemental EIS should provide an analysis of the potential social, economic, and environmental impacts of a major oil event to fish stocks and to commercial and recreational fisheries in the Gulf of Mexico. Additionally, the Supplemental EIS should include an analysis of the potential effects of a major spill event to seafood, including wild-caught finfish and shellfish and aquaculture products that are important components of the Nation's food supply. These analyses should consider fishery closures, impacts to food safety, and contamination by hydrocarbon compounds and dispersants. • The Environmental Sensitivity Index used in past programs does not consider the sensitivity of marine habitats in the OCS to oil spills or other activities associated with oil and gas exploration, development, or production. The NOAA suggests that BOEMRE broaden the scope of its analysis to consider the impacts of all activities, including potential oil-spills and the use of chemical dispersants in any oil spill response efforts, to EFH and other vulnerable deepwater habitats such as deep-sea corals. The NOAA also suggests that BOEMRE evaluate the potential impacts to EFH for each life stage of each managed species, as well as impacts to other vulnerable habitats, from a worst-case scenario spill, including impacts to benthic and pelagic coastal and offshore habitats and prepare proposed mitigation requirements for such a spill. • The NOAA provided a list of 14 habitat areas of particular concern, which are designated within the Western and Central Planning Areas.

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
National Oceanic and Atmospheric Administration, National Marine Fisheries Service St. Petersburg, FL	• The EFH section of the Supplemental EIS should reflect the current EFH identifications and descriptions by the Gulf of Mexico Fishery Management Council in 2005 for Council-managed species and by NMFS for highly migratory species in 2009. • The NOAA recommends a recalculation of the likelihood of a major oil-spill event and an analysis of the effects from oil spills that utilize the flow rates and quantities identified in the "Oil Budget Calculator Deepwater Horizon Technical Documentation." Additionally, the Supplemental EIS should reanalyze the effects of dispersant application and in-situ burning. • If the proposed activity may affect a listed species or designated critical habitat, BOEMRE must initiate consultation with NMFS pursuant to Section 7 of the ESA. • The NMFS would like to work with BOEMRE to enhance, refine, or develop new oil-spill analyses to improve the understanding of the effects of oil spills on listed species and to improve the Section 7 consultation. The NMFS recommends that spill probabilities and modeling of different sized spills, including catastrophic spills, be provided for sources of spills in offshore and nearshore environment and for surface and deepwater sources. The NMFS also asks BOEMRE to provide additional information regarding the relative risk of exploration and production wells leaking oil on the continental shelf versus those located on the continental slope and deepwater Gulf of Mexico. • The NOAA recommends that revised spill probabilities and modeling of different sized spills, including catastrophic spills for the Gulf of Mexico for sources of spills in offshore and nearshore environments be conducted. These models must include both surface and deepwater sources, as well as the effects of oil-spill response plans (e.g., dispersants) on the fate of the oil in the models. The Supplemental EIS should consider the variety and magnitude of effects associated with the chance of an oil spill taking listed species and adversely modifying or destroying critical habitat. • Please describe any changes to the proposed action resulting from the Deepwater Horizon event, including safety, spill contingency planning, spill response, and restoration actions. Also include any new programs and safeguards to reduce the likelihood of spills occurring in the future and provide an analysis of any new information and the potential for impacts to occur on listed species and critical habitat. • The Supplemental EIS should define the proposed lease sale areas, air permit requirements, and types of operations that fall under the jurisdictions of both BOEMRE and USEPA. The USEPA may be included as a co-agency in the biological opinion for air emissions for lease areas under their jurisdiction and should be included in any such request for ESA consultation. • The NMFS recommends that BOEMRE conduct a study to better understand the cumulative effects of noise from oil and gas construction and development activities on the OCS. This recommendation includes characterizing all aspects of noise-producing construction and operation activities such as pile driving during well construction and platform installation, and other common OCS activities. Major noise-producing activities (>120 dB re 1 μPa_{rms}) should be identified, and measurements of noise from these activities should be reported in appropriate units of measurement to estimate the acoustic footprint on the environment, duration, frequency, and relative contribution to ambient noise levels in the Gulf of Mexico. • The BOEMRE should consider a data collection program for the protected species observer program in coordination with NMFS, and include the program in the Supplemental EIS as appropriate.

Table 5-1. Scoping Comments (continued).

Name and Affiliation	Concerns
National Oceanic and Atmospheric Administration, National Marine Fisheries Service St. Petersburg, FL	• Pipeline construction may affect habitats important to listed species and should be considered in the Supplemental EIS. • The BOEMRE should continue to work with NMFS and the Offshore Operators Committee to provide informational materials to the offshore oil and gas workers, require annual training, and continue to develop best management practices to reduce the release of debris into the marine environment. The BOEMRE should work with NMFS to update the Marine Debris Notice to Lessees (NTL) 2003-G11 and apply this to other geographic areas/regions as appropriate. • The NOAA recommends that the Vessel Strike Avoidance Measures and Reporting for Mariners be applied throughout approved lease areas. • The Supplemental EIS should characterize all noise sources with source levels above 120 dB re 1 μPa_{rms} as the potential to affect marine mammals and other listed species. • Many general impacts associated with the construction and operation of oil and gas structures should be considered in the Supplemental EIS. Habitat alterations to water quality may result from accidental spills, turbidity during terminal an pipeline construction, wastewater discharges, and warming water outflow. Habitat effects may also occur from propeller wash, benthic impacts from pipeline and terminal construction, and discharges of marine debris. • In the event that any aspect of a proposed oil and gas operation will result in a “take,” the oil and gas applicant, or the lead agency acting on behalf of the applicant, would be required to obtain an incidental take authorization from NOAA. • The NOAA had two primary comments on the Supplemental EIS related to national marine sanctuaries: (1) NOAA requests that BOEMRE review the designation of all No-Activity Zones associated with all of the topographic features in the Central and Western Planning Area, and re-establish these areas based on current bathymetric and biological data; and (2) NOAA requests that BOEMRE require the shunting of material from all wells drilled within the specified buffer zones around the No-Activity Zones. • As BOEMRE considers scoping for the Supplemental EIS, BOEMRE should consider the following issues: (1) potential and cumulative impacts on the mesophotic and deep-sea communities during the development of oil and gas resources; (2) potential and cumulative impacts on mesophotic and deep-sea coral communities in the siting of undersea pipelines; (3) potential and cumulative impacts on mesophotic and deep-sea coral communities in the event of a major spill; recent findings from research conducted to assess impacts from the *Deepwater Horizon* spill on deep-sea coral communities should be helpful in considering these impacts; (4) potential and cumulative impacts on shallow coral reef, mesophotic and deep-sea coral communities connected by prevailing ocean currents to the lease sites; and (5) potential and cumulative socioeconomic impacts to communities dependent on recreational and commercial fishing in the lease areas, as well as communities dependent on coastal and ocean tourism and fishing in places connected by prevailing ocean currents.

References Cited

Alonso-Alvarez, C., I. Munilla, M. Lòpez-Alonso, and A. Velando. 2007. Sublethal toxicity of the Prestige oil spill on yellow-legged gulls. Environment International 33:773-781.

Anderson, C.M. and R.P. LaBelle. 2000. Update of comparative occurrence rates for offshore oil spills. Spill Science and Technology Bulletin 6(5/6):302-321.

Atkins, M., T. Edward, D. Johnson, and M. Dance. 2007. Pipeline damage assessment from Hurricanes Katrina and Rita in the Gulf of Mexico. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 581.

Banks, A.N., W.G. Sanderson, B. Hughes, P.A. Cranswick, L.E. Smith, S. Whitehead, A.J. Musgrove, B. Haycock, and N.P. Fairney. 2008. The *Sea Empress* oil spill (Wales, UK): Effects on common scoter *Melanitta nigra* in Carmarthen Bay and status ten years later. Marine Pollution Bulletin 56:895-902.

British Petroleum. 2011a. Waste disposal and recoverable facilities (current and potential locations). Internet website: http://usresponse.bp.com/external/content/document/2911/995083/1/Waste_Disposal_Locations%20%2012511.pdf. Accessed March 20, 2011.

British Petroleum. 2011b. MC 252 weekly waste tracking cumulative report by disposal facility: Report for the weeks of 04/04/2011 to 04/10/11; consolidated report. 22 pp. Internet website: http://usresponse.bp.com/external/content/document/2911/1066495/1/Consolidated_Weekly_Report_04102011_Disposal_Facility.pdf. Accessed March 20, 2011.

Brooks, J.M. and C.P. Giammona. 1990. Mississippi-Alabama marine ecosystem study: Annual report; Year 2. Volume I: Technical narrative. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 89-0095. 348 pp.

Burger, A.E. 1993. Estimating the mortality of seabirds following oil spills: Effects of spill volume. Marine Pollution Bulletin 26:140-143.

Byrd, G.V., J.H. Reynolds, and P.L. Flint. 2009. Persistence rates and detection probabilities of bird carcasses on beaches of Unalaska Island, Alaska, following the wreck of the M/V *Selendang Ayu*. Marine Ornithology 37:197-204.

Cadiou, B., L. Riffaut, K.D. McCoy, J. Cabelguen, M. Fortin, G. Gélinaud, A. Le Roch, C. Tirard, and T. Boulinier. 2004. Ecological impact of the "*Erika*" oil spill: Determination of the geographic origin of the affected common guillemots. Aquatic Living Resources 17:369-377.

Camphuysen, K., M. Heubeck, S.L. Cox, R. Bao, D. Humple, C. Abraham, and A. Sandoval. 2002. The *Prestige* oil spill in Spain. Atlantic Birds 4:131-140.

Canadian Center for Energy Information. 2010. What are oil sands and heavy oil? Internet website: http://www.centreforenergy.com/AboutEnergy/ONG/OilsandsHeavyOil/Overview.asp?page=1. Accessed September 27, 2010.

Castège, I., G. Hèmery, N. Roux, J. D'Elbèe, Y. Lalanne, F. D'Amico, and C. Mouchès. 2004. Changes in abundance and at-sea distribution of seabirds in the Bay of Biscay prior to, and following the "Erika" oil spill. Aquatic Living Resources 17:369-377.

Castège, I., Y. Lalanne, V. Gouriou, G. Hèmery, M. Girin, F. D'Amico, C. Mouchès, J. D'Elbèe, L. Soulier, J. Pensu, D. Lafitte, and F. Pautrizel. 2007. Estimating the actual seabirds mortality at sea and relationship with oil spills: Lesson from the "Prestige" oil spill in Aquitaine (France). Ardeola 54:289-307.

Chapman, B.R. 1981. Effects of *Ixtoc I* oil spill on Texas shorebird populations. In: Proceedings of the 7th International Oil Spill Conference, Atlanta, GA. Washington, DC: American Petroleum Institute. Pp. 461-465.

Chapman, B.R. 1984. Seasonal abundance and habitat-use patterns of coastal bird populations on Padre and Mustang Island barrier beaches (following the *Ixtoc I* oil spill). U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-83/31. 73 pp. Internet website: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3850.pdf.

Devers, W. 2010. Written communication. Long Beach fish kills report. Marine fisheries scientist, Mississippi Dept. of Marine Sciences. September 27, 2010.

Dickey, D. 2006. Personal communication. U.S. Dept. of Transportation, Coast Guard. Headquarters Office of Compliance and Analysis, Washington DC. June 28, 2006.

Dickey, D. 2010. Personal communication. Oil-spill events (2008). U.S. Dept. of Transportation, Coast Guard, Headquarters Office of Compliance and Analysis, Washington DC. April 26, 2010.

Dismukes, D.E. In preparation. Fact book: OCS-related energy infrastructure and post-hurricane impact assessment. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA.

Energo Engineering. 2010. Assessment of damage and failure mechanisms for offshore structures and pipelines in Hurricanes Gustav and Ike. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. TA&R 642.

Federal Register. 2010. Increased safety measures for energy development on the outer continental shelf. 75 FR 198, 63346-63377. Internet website: http://www.gpo.gov/fdsys/pkg/FR-2010-10-14/pdf/2010-25256.pdf.

Flint, P.L. and A.C. Fowler. 1998. A drift experiment to assess the influence of wind on recovery of oiled seabird on St. Paul Island, Alaska. Marine Pollution Bulletin 36:165-166.

Flint, P.L., A.C. Fowler, and R.F. Rockwell. 1999. Modeling bird mortality associated with the M/V *Citrus* oil spill off St. Paul Island, Alaska. Ecological Modelling 117:261-267.

Flint, P.L., E.W. Lance, K.M. Sowl, and T.F. Donnelly. 2010. Estimating carcass persistence and scavenging bias in a human-influenced landscape in western Alaska. Journal of Field Ornithology 81:206-214.

Ford, R.G., M.L. Bonnell, D.H. Varoujean, G.W. Page, H.R. Carter, B.E. Sharp, D. Heinemann, and J.L. Casey. 1996. Total direct mortality of seabirds from the *Exxon Valdez* oil spill. American Fisheries Society Symposium 18:684-711.

Fowler, A.C. and P.L. Flint. 1997. Persistence rates and detection probabilities of oiled king eider carcasses on St. Paul Island, Alaska. Marine Pollution Bulletin 34:522-526.

Gardner, J.V., P. Dartnell, and K.J. Sulak. 2002. Multibeam mapping of the pinnacles region, Gulf of Mexico. U.S. Dept. of the Interior, Geological Survey. Open File Report OF02-006. Internet website: http://geopubs.wr.usgs.gov/open-file/of02-006/. Accessed September 9, 2010.

Gulf Coast Claims Facility. 2010. Frequently asked questions. Internet website: http://gulfcoastclaimsfacility.com/faq#Q11. Accessed January 23, 2011.

Gulf Coast Claims Facility. 2011. Statistics and overall summary, and state status reports (April 27, 2011). Internet website: http://www.gulfcoastclaimsfacility.com/reports. Accessed April 28, 2011.

Helm, R.C., R.G. Ford, and H.R. Carter. 2006. The Oil Pollution Act of 1990 and Natural Resources Damage Assessment. Marine Ornithology 34:99-108.

Helm, R.C., R.G. Ford, and H.R. Carter. 2008. Oil spills, seabirds, and NRDA: Differences between U.S. West, East, and Gulf Coasts. In: Proceedings of the 20th International Oil Spill Conference, Savannah, GA, USA. Washington, DC: American Petroleum Institute. Pp. 1131-1139. Internet website: http://www.iosc.org/papers/2008%20193.pdf.

Jernelöv, A. 2010. The threats from oil spills: Now, then, and in the future. Ambio 39:353-366. Internet website: http://www.springerlink.com/content/303223683645l54u/fulltext.pdf.

Kaplan, M.F. and C. Whitman. Unpublished. Measuring the economic impact of tourism and recreation industries on Gulf Coast communities—Relationship between OCS development and coastal resources (2008). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Contract No. 1435-01-99-CA-30951-18261. x + 164 pp.

King, J.G. and G.A. Sanger. 1979. Oil vulnerability index for marine oriented birds. In: Bartonek, J.C. and D.N. Nettleship, eds. Conservation of marine birds in North America. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, DC. Wildlife Research Report Number 11. Pp. 227-239. Internet website: http://www.archive.org/stream/conservationofma00naturich#page/n3/mode/2up. Accessed March 25, 2011.

Law, R.J. and C. Kelley. 2004. The impact of the "Sea Impress" oil spill. Aquatic Living Resources 17:389-394.

Louisiana Dept. of Natural Resources. 2010. Production information. SONRIS lite: Internet database. Internet website: http://sonris-www.dnr.state.la.us/www_root/sonris_portal_1.htm. Accessed October 6, 2010.

Michel, J. 1992. Chapter 2. Oil behavior and toxicity. In: Introduction to coastal habitats and biological resources for spill response. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. NOAA Report No. HMRAD 92-4. Internet website: http://response.restoration.noaa.gov/type_subtopic_entry.php?RECORD_KEY%28entry_subtopic_type%29=entry_id,subtopic_id,type_id&entry_id(entry_subtopic_type)=275&subtopic_id(entry_subtopic_type)=8&type_id(entry_subtopic_type)=2. Accessed March 22, 2011.

Munilla, I. and A. Velando. 2010. Oiling of live gulls as a tool to monitor acute oil spill effects on seabirds. Ibis 152:405-409.

National Academy of Engineering (NAE) and National Research Council (NRC). 2011. Blowout prevention: Analysis of the *Deepwater Horizon* explosion, fire, and oil spill. Internet website: http://sites.nationalacademies.org/BlowoutPrevention/index.htm. Accessed March 15, 2011.

National Archives and Records Administration. 2010. Electronic Code of Federal Regulations. Internet website: http://www.archives.gov/. Accessed January 27, 2011.

National Ocean Economics Program. 2006. Oil & gas production. Internet website: http://noep.csumb.edu/Minerals/oil_gas.asp. Accessed September 11, 2006.

Oil Spill Commission. 2010. The amount and fate of the oil. Staff Working Paper No. 3. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 29 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/Working%20Paper.Amount%20and%20Fate.For%20Release.pdf.

Oil Spill Commission. 2011. Deep water: The Gulf oil disaster and the future of offshore drilling. Report to the President, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 398 pp. Internet website: http://www.oilspillcommission.gov/final-report. Accessed March 15, 2011.

Piatt, J.F. and R.G. Ford. 1996. How many seabirds were killed by the *Exxon Valdez* oil spill? American Fisheries Society Symposium 18:712-719.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek, and D.R. Nysewander. 1990a. Immediate impact of the *Exxon Valdez* oil spill on seabirds. Auk 107:387-397.

Piatt, J.F., H.R. Carter, and D.N. Nettleship. 1990b. Effects of oil pollution in marine bird populations. In: White, J., ed. The effects of oil on wildlife: Research, rehabilitation and general concerns. Proceedings of the Oil Symposium, Herndon, VA, October 16-18, 1990. Hanover, PA: Sheridan Press. Pp. 125-141.

RestoreTheGulf.gov. 2011. Transcripts and docs. Internet website: http://www.restorethegulf.gov/news/transcripts-docs. Accessed March 11, 2011.

Schroeder, W.W., A.W. Shultz, and J.J. Dindo. 1988. Inner-shelf hardbottom areas, northeastern Gulf of Mexico. Trans. Gulf Coast Assoc. Geol. Soc. 38:535-541.

Shipp, R.L. and T.L. Hopkins. 1978. Physical and biological observations of the northern rim of the DeSoto Canyon made from a research submersible. N.E. Gulf Sci. 2(2):113-121.

Tan, L., M. Belanger, and C. Wittnich. 2010. Revisiting the correlation between estimated seabird mortality and oil spill size. Journal of Marine Animals and Their Ecology 3:20-26.

U.S. Dept of Agriculture. Forest Service. 2010. National survey on recreation and the environment, 2005-2009. U.S. Dept. of Agriculture, Forest Service, Southern Research Station.

U.S. Dept. of Commerce. Census Bureau. 2010. State and county quick facts. Internet website: http://quickfacts.census.gov/qfd/states/22000.html. Last revised November 4, 2010. Accessed April 2011.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010a. *Deepwater Horizon* oil: Characteristics and concerns. National Ocean Service. 2 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/OilCharacteristics.pdf. Last revised May 15, 2010. Accessed August 27, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010b. National Hurricane Center, Miami, FL. Internet website: http://www.nhc.noaa.gov. Accessed November 16, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010c. 2008—Fisheries economics of the U.S. Internet website: http://www.st.nmfs.noaa.gov/st5/publication/fisheries_economics_2008.html#. Accessed December 1, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010d. Recreational fisheries statistics queries. Internet website: http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. Accessed December 1, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2011. *Deepwater Horizon* MC 252 waste management sites. Internet website: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/incident_response/STAGING/local_assets/downloads_pdfs/wastemgnt_7282010.pdf . Accessed May 16, 2011.

U.S. Dept. of Energy. Energy Information Administration. 2006. Petroleum and other liquids. Internet website: http://www.eia.doe.gov/oil_gas/petroleum/info_glance/petroleum.html. Accessed September 11, 2006.

U.S. Dept. of Labor. Bureau of Labor Statistics. 2010. Quarterly census of employment and wages. Internet website: http://www.bls.gov/cew/home.htm. Accessed December 1, 2010.

U.S. Dept. of the Army. Corps of Engineers. 2011. Amount of dredged material ocean disposed by year in cubic yards by single district. Internet website: http://el.erdc.usace.army.mil/odd/. Stated as current through 2008. Accessed January 27, 2011.

U.S. Dept. of the Interior. 2010a. Increased safety measures for energy development on the outer continental shelf, May 27, 2010. U.S. Dept. of the Interior, Washington, DC. 44 pp. Internet website: http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=33598. Accessed March 13, 2011.

U.S. Dept. of the Interior. 2010b. Outer Continental Shelf Safety Oversight Board, report to Secretary of the Interior Ken Salazar. U.S. Dept. of the Interior, Washington, DC. September 1, 2010. 37 pp. Internet website: http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=43677. Accessed March 13, 2011.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010. Bird impact data from DOI-ERDC database download 30 Nov. 2010: Weekly bird impact data and consolidated wildlife reports. 3 pp. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/Bird%20Data%20Species%20Spreadsheet%2011302010.pdf.

U.S. Dept. of the Interior, Fish and Wildlife Service, and U.S. Dept. of Commerce, Census Bureau. 2006. 2006 national survey of fishing, hunting, and wildlife-associated recreation. FHW/06-NAT. 168 pp. Internet website: http://www.census.gov/prod/2008pubs/fhw06-nat.pdf.

U.S. Dept. of the Interior. Office of the Inspector General. 2010. A new horizon: Looking to the future of the Bureau of Ocean Energy Management, Regulation and Enforcement. No. CR-EV-MMS-0015-2010. Washington, DC. 82 pp. Internet website: http://www.doioig.gov/images/stories/reports/pdf/A%20New%20Horizon%20Public.pdf.

U.S. Dept. of Transportation. Coast Guard. 2001. Polluting incident compendium: Cumulative data and graphics for oil spills, 1973-2000. Internet website: http://www.uscg.mil/hq/g-m/nmc/response/stats/summary.htm.

U.S. Dept. of Transportation. Maritime Administration (MARAD). 2009. Vessel calls snapshot, 2009. 10 pp. Internet website: http://www.marad.dot.gov/documents/Vessel_Calls_at_US_Ports_Snapshot.pdf.

U.S. Environmental Protection Agency. 2008. National list of beaches. U.S. Environmental Protection Agency, Office of Water. EPA-823-R-08-004. 160 pp.

U.S. Environmental Protection Agency. 2011. 8-hour ozone nonattainment area/state/county report. Internet website: http://www.epa.gov/oaqps001/greenbk/gnca.html. Accessed April 28, 2011.

U.S. Environmental Protection Agency and British Petroleum. 2010. Unified Area Command Plan—Deepwater Horizon MC252: Waste and material tracking system and reporting plan. Internet website: http://www.epa.gov/bpspill/waste/bp_waste_tracking_plan.pdf. Issued August 20, 2010. Accessed October 8, 2010.

U.S. Travel Association. 2010. Economic impact of travel and tourism. The Power of Travel Data Center. Internet website: http://poweroftravel.org/statistics. Accessed December 14, 2010.

Velando, A., D. Álvarez, J. Mouriño, F. Arcos, and Á. Barros. 2005a. Population trends and reproductive success of the European shag *Phalocrocorax aristotelis* on the Iberian Peninsula following the *Prestige* oil spill. Journal of Ornithology 146:116-120.

Velando, A., I. Munilla, and P.M. Leyenda. 2005b. Short-term indirect effects of the *Prestige* oil spill on European shags: Changes in availability of prey. Marine Ecology Progress Series 302:263-274.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, eds. 2009. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2009. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NMFS NE 213. 528 pp.

Weaver, D.C., G.D. Dennis, and K.J. Sulak. 2002. Northeastern Gulf of Mexico coastal marine ecosystem program: Community structure and trophic ecology of demersal fishes on the pinnacle reef tract: Final synthesis report. U.S. Dept. of the Interior, Geological Survey, USGS BSR-2001-008 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-034. 143 pp.

Wiens, J.A., R.G. Ford, and D. Heinemann. 1984. Information needs and priorities for assessing the sensitivity of marine birds to oil spills. Biological Conservation 28:21-49.

Wiese, F.K. and I.L. Jones. 2001. Experimental support for a new drift block design to assess seabird mortality from oil pollution. Auk 118:1062-1068.

Wilhelm, S.I., G.J. Robertson, P.C. Ryan, and D.C. Schneider. 2007. Comparing an estimate of seabirds at risk to a mortality estimate from the November 2004 *Terra Nova* FPSO oil spill. Marine Pollution Bulletin 54:537-544.

Williams, J.M., M.L. Tasker, I.C. Carter, and A. Webb. 1995. A method of assessing seabird vulnerability to surface pollutants. Ibis 137:S147-S152.

Woods & Poole Economics, Inc. 2010. The 2011 complete economic and demographic data source (CEDDS) on CD-ROM.

APPENDIX B

CATASTROPHIC SPILL EVENT ANALYSIS

APPENDIX B. CATASTROPHIC SPILL EVENT ANALYSIS

1. INTRODUCTION

In 1986, the Council on Environmental Quality (CEQ) regulations were amended to rescind the requirement to prepare a “worst-case analysis” for an Environmental Impact Statement (EIS). *See* 40 C.F.R. § 1502.22(b)(4). The regulation, as amended, states that catastrophic, low-probability impacts must be analyzed if the analysis is “supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.”

The August 16, 2010, CEQ report, prepared following the *Deepwater Horizon* blowout and spill in the Gulf of Mexico (CEQ, 2010), recommended that the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), should “ensure that NEPA documents provide decisionmakers with a robust analysis of reasonably foreseeable impacts, including an analysis of reasonably foreseeable impacts associated with low probability catastrophic spills for oil and gas activities on the Outer Continental Shelf” (CEQ, 2010). This Analysis provides that robust analysis of the impacts of low-probability catastrophic spills for all applicable decisionmakers including, but not limited to, the Secretary of the Department of the Interior (USDOI) for the National 5-Year Program, the Assistant Secretary of Land Management for an oil and gas lease sale, or the Regional Supervisor of the Office of Field Operations for an exploration or development plan.

1.1. WHAT IS A CATASTROPHIC EVENT?

As applicable to NEPA, Eccleston (2008) defines a catastrophic event as “large-scale damage involving destruction of species, ecosystems, infrastructure, or property with long-term effects, and/or major loss of human life.” For oil and gas activities on the Outer Continental Shelf (OCS), a catastrophic event is a high-volume, long-duration oil spill regardless of the cause, whether natural disaster (i.e., hurricane) or manmade (i.e., human error and terrorism). This high-volume, long-duration oil spill, or catastrophic spill, has been further defined by the National Oil and Hazardous Substances Pollution Contingency Plan as a “spill of national significance” or “a spill which due to its severity, size, location, actual or potential impact on the public health and welfare or the environment, or the necessary response effort, is so complex that it requires extraordinary coordination of federal, state, local, and responsible party resources to contain and cleanup the discharge” (40 C.F.R. Part 300, Appendix E).

Each oil-spill event is unique; its outcome depends on several factors, including time of year and location of release relative to winds, currents, land, and sensitive resources, specifics of the well (i.e., flow rates, hydrocarbon characteristics, and infrastructure damage), and response (i.e., speed and effectiveness). For this reason, the severity of an oil spill cannot be predicted based on volume alone, although a minimum volume of oil must be spilled to reach catastrophic impacts.

Though large spills may result from a pipeline rupture, this likely will not result in a catastrophic spill because the ability to detect leaks and shut off pipelines limits the spill to the contents of the pipeline. The largest, non-blowout-related spill on the Gulf of Mexico OCS occurred in 1967, a result of internal pipeline corrosion caused by anchor damage. In 13 days, 160,638 barrels of oil leaked (USDOI, BOEMRE, 2010a); however, no significant environmental impacts were recorded as a result of this spill.

Loss of well control creates the volume and duration that produces a catastrophic oil spill. Although loss of well control is defined as the uncontrolled flow of a reservoir fluid that may result in the release of gas, condensate, oil, drilling fluids, sand, or water, it is a broad term that includes very minor well control incidents as well as the most severe well control incidents. Historically, loss of well control incidents occurred during development drilling operations, but loss of well control incidents can occur during exploratory drilling, production, well completions, or workover operations. These losses of well control incidents may occur between zones in the wellbore or at the seafloor.

Blowouts are a more severe loss of well subset with that create a greater risk of an oil spill and human injury. Two blowouts that resulted in catastrophic spills have occurred in U.S. and Mexican waters of the Gulf of Mexico. In 1979, the *Ixtoc* blowout in shallow water (164 feet [ft] 50 miles (mi) offshore in the Bay of Campeche, Mexico), spilled 3.5 million barrels of oil spilled in 10 months (USDOC, NOAA, Office of Response and Restoration, 2010a; USDOC, NOAA, Hazardous Materials Response and Assessment Division, 1992; ERCO, 1982). In 2010, the *Deepwater Horizon* blowout, in deepwater

(4,992 ft) 48 mi offshore in Mississippi Canyon Block 252, spilled an estimated 4.9 million barrels of oil until it was capped almost 3 months later.

Prior to the *Deepwater Horizon* incident, the two largest spills in U.S. waters of the Gulf of Mexico OCS resulting from a loss of well control occurred in 1970 and released 30,000 and 53,000 barrels of oil (USDOI, BOEMRE, 2010a). These incidents resulted in four human fatalities. Although only 8-14 miles from shore, there was minor shoreline contact (USDOC, NOAA, Office of Response and Restoration, 2010b and 2010c). In 1987, a blowout of the Mexican exploratory oil well, YUM II, resulted in a spill of 58,640 barrels and 75 miles of impacted shoreline (USDOC, NOAA, Hazardous Materials Response and Assessment Division, 1992). None of these spills met the definition of a catastrophic event or spill.

For this reason, only the *Ixtoc* and *Deepwater Horizon* blowouts and spills are analyzed below.

1.2. Methodology

Two general approaches are utilized to analyze a catastrophic event under NEPA. The first approach is a bounding analysis for each individual resource category (e.g., marine mammals, sea turtles, etc.). This requires selecting a different set of factors and scenarios for each resource affected by a worst-case analysis. The second approach selects a single set of key circumstances that, in combination, result in catastrophic consequences. This creates a site-specific analysis with limited usefulness in future NEPA documents and consultations. Accordingly, this analysis combines the two approaches, relying on a generalized scenario while identifying site-specific severity factors for individual resources. This combined approach allows for the scientific investigation of a range of possible, although not necessarily probable, consequences of a catastrophic blowout and oil spill in the Gulf of Mexico.

1.2.1. Geographic Scope

Because the Gulf of Mexico is a semi-enclosed basin with an extensive history of oil and gas activities and with unique environmental conditions and hydrocarbon reservoir properties, this analysis is applicable to the Gulf of Mexico OCS only. It is not intended for other OCS regions.

When possible, this analysis distinguishes between shallow water (<1,000 feet) and deep water (≥1,000 feet).

1.2.2. Impact-Producing Factors and Scenario

A hypothetical, yet feasible, scenario was developed to provide a framework for identifying the impacts of an extended oil spill from an uncontrolled blowout in both shallow and deep water. Unless noted, this scenario is based on the larger magnitude, blowout-related oil spills that have occurred in the Gulf of Mexico, discussed in Section 1.1. As noted above, because each spill event is unique, its outcome depends on many factors. Therefore, this scenario cannot predict the outcome of present or future spills.

1.2.3. Environmental and Socioeconomic Impacts

This analysis evaluates the impacts to the Gulf of Mexico's coastal, marine, environmental, and socioeconomic resources from a catastrophic blowout, oil spill and its associated cleanup activities.

Although the most recent EIS's prepared by MMS for oil and gas lease sales in the Gulf of Mexico analyze the potential impacts from smaller oil spills that are more reasonably foreseeable (USDOI, MMS, 2007 and 2008), the analysis below focuses on the most likely and most significant impacts created by a high-volume, extended-duration spill. Because catastrophic consequences may not occur for all resources, factors affecting the severity of impacts are identified by individual resource.

1.3. How to Use This Analysis

The purpose of this technical analysis is to assist BOEMRE in meeting CEQ requirements (40 C.F.R. § 1502.22) for analysis of catastrophic, low-probability impacts if the analysis is "supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason." Therefore, this analysis identifies the most likely and most significant impacts from a high-volume blowout and oil spill that continues for an extended period of time. The scenario and impacts discussed in this analysis should

not be confused with the scenario and impacts anticipated to result from routine activities or more reasonably foreseeable accidental events of a proposed action.

This technical analysis is designed to be incorporated by reference in future NEPA documents and consultations. Therefore, factors that affect the severity of impacts of a high-volume, extended-duration spill are highlighted throughout the analysis for use in subsequent site-specific analyses.

To analyze a hypothetical catastrophic event in an area such as the Gulf of Mexico, several assumptions and generalizations were made. However, future project-specific analyses should also consider specific details such as potential flow rates for the specific proposed activity, the properties of the targeted reservoir, and distance to shore of the proposed activities.

The life cycle of a catastrophic blowout and spill is divided into four geographic areas and/or time periods, some of which may overlap:

- Phase 1: Initial event (Section 2)
- Phase 2: Offshore spill (Section 3)
- Phase 3: Onshore contact (Section 4)
- Phase 4: Post-spill, long-term recovery (Section 5)

Each phase of a catastrophic oil spill is addressed in this analysis. For each phase, the scenario is described, factors that could produce environmental impacts are listed, and the most likely and most significant impacts are discussed.

2. INITIAL EVENT (PHASE 1)

While most of the environmental and socioeconomic impacts of a catastrophic blowout would occur during the ensuing high-volume, extended-duration spill (see Sections 3, 4, and 5), it is important to acknowledge the deadly events that could occur in the initial phase of a catastrophic blowout. The following scenario was developed to provide a framework for identifying the most likely and most significant impacts during the initial phase.

2.1. Impact-Producing Factors and Scenario

Phase 1 of the scenario is the initial incident of a catastrophic blowout. Impacts, response, and intervention depend on the spatial location of the blowout and leak. While there are several points where a blowout could occur, four major distinctions that are important to the analysis of impacts are described in Table 1 below.

For this analysis, an explosion and subsequent fire are assumed to occur. If a blowout associated with the drilling of a single exploratory well occurs, this could result in a fire that would burn for 1 or 2 days. If a blowout occurs on a production platform, other wells could feed the fire, allowing it to burn for over a month (USDOC, NOAA, Office of Response and Restoration, 2010c). The drilling rig or platform may sink. If the blowout occurs in shallow water, the sinking rig or platform may land in the immediate vicinity; if the blowout occurs in deep water, the rig or platform could land a great distance away, beyond avoidance zones. For example, the *Deepwater Horizon* drilling rig sank, landing 1,500 feet away on the seafloor. Regardless of water depth, the immediate response would be from search and rescue vessels and aircraft, such as United States Coast Guard (USCG) cutters, helicopters, and rescue planes, and firefighting vessels.

Table 1

Blowout Scenarios and Key Differences
in Impacts, Response, and/or Intervention

Location of Blowout and Leak	Key Differences in Impacts, Response, and/or Intervention
Blowout occurs at the sea surface (i.e., at the rig)	Offers the least chance for oil recovery due to the restricted access to the release point; therefore, greater impacts to coastal ecosystems. In addition to relief wells, there is potential for other intervention measures such as capping and possible manual activation of Blow-Out-Preventer (BOP) rams.
Blowout occurs along the riser anywhere from the seafloor to the sea surface. However, a severed riser would likely collapse, resulting in a leak at the seafloor.	In deep water, the use of subsea dispersants may reduce impacts to coastal ecosystems; however, their use may increase exposure of marine resources to oil. There is a possibility for limited recovery of oil at the source. In addition to relief wells, there is potential for other intervention measures, such as capping and possible manual activation of BOP rams.
At the seafloor, through leak paths on the BOP/wellhead	In deep water, the use of subsea dispersants may reduce impacts to coastal ecosystems; however, their use may increase exposure of deepwater marine resources to dispersed oil. With an intact subsea BOP, intervention may involve the use of drilling mud to kill the well. If the BOP and well stack are heavily compromised, the only intervention method may be relief wells. Greatest possibility for recovery of oil at the source, until the well is capped or killed.
Below the seafloor, outside the wellbore (i.e., broached)	Disturbance of a large amount of sediments resulting in the burial of benthic resources in the immediate vicinity of the blowout. The use of subsea dispersants would likely be more difficult (PCCI, 1999). Stopping this kind of blowout would probably involve relief wells. Any recovery of oil at the seabed would be very difficult.

2.2. MOST LIKELY AND MOST SIGNIFICANT IMPACTS

Impacts during Phase 1 would be limited to environmental resources in the immediate vicinity of the blowout. The most recent EIS's prepared by MMS for oil and gas lease sales in the Gulf of Mexico detail the potential impacts from reasonably foreseeable blowouts (USDOI, MMS, 2007 and 2008). In addition to the impacts described in those documents, the most likely and most significant impacts resulting from a catastrophic blowout outside the wellbore are described below.

2.2.1. Physical Resources

2.2.1.1. Air Quality

A catastrophic blowout close to the water surface would initially emit large amounts of methane and other gases into the atmosphere. If high concentrations of sulfur are present in the produced gas, hydrogen sulfide (H_2S) could present a hazard to personnel. The natural gas H_2S concentrations in the Gulf of Mexico OCS are generally low; however, there are areas such as the Norphlet formation in the northeastern Gulf of Mexico, for example, that contain levels of H_2S up to 9 percent. Ignition of the blowout gas and subsequent fire would result in emissions of nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOC's), particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). The fire could also produce polycyclic aromatic hydrocarbons (PAH's), which are known to be hazardous to human health. The pollutant concentrations would decrease with downwind distance. A large plume of black smoke would be visible at the source and may extend a considerable distance downwind. However, with increasing distance from the fire, the gaseous pollutants would

undergo chemical reactions, resulting in the formation of fine particulate matter ($PM_{2.5}$) that includes nitrates, sulfates, and organic matter. The $PM_{2.5}$ concentrations in the plume would have the potential to temporarily degrade visibility in any affected Prevention of Significant Deterioration (PSD) Class I areas (i.e., National Wilderness Areas and National Parks) and other areas where visibility is of significant value.

2.2.1.2. Offshore Water Quality

During the initial phase of a catastrophic blowout, water quality impacts include disturbance of sediments and release and suspension of oil and natural gas (methane) into the water column. These potential impacts are discussed below. As this section deals with the immediate effects of a blowout that would be located at least 3 nautical mi from shore, it is assumed that there would be no impacts on coastal water quality during this initial stage.

Disturbance of Sediments

A catastrophic blowout below the seafloor, outside the wellbore (Table 1) has the potential to resuspend sediments and disperse potentially large quantities of bottom sediments. Some sediment could travel several kilometers, depending on particle size and subsea current patterns. In the deep Gulf of Mexico, surficial sediments are mostly composed of silt and clay, and, if resuspended, could stay in the water column for several hours to even days. Bottom currents in the deep Gulf of Mexico have been measured to reach 30 centimeters/second (cm/sec) with mean flows of 1.5-2.5 cm/sec (Hamilton, 1990). At these mean flow rates, resuspended sediment could be transported 1.3-2.1 kilometers/day. Sediment resuspension can lead to a temporary change in the oxidation-reduction chemistry in the water column, including a localized and temporal release of any formally sorbed metals, as well as nutrient recycling (Caetano et al., 2003; Fanning et al., 1982). Sediments also have the potential to become contaminated with oil components.

A subsea release also has the potential to destabilize the sediments and create slumping or larger scale sediment movements along depth gradients. These types of events would have the potential to move and/or damage any infrastructure in the affected area.

Release and Suspension of Oil into the Water Column

As the *Deepwater Horizon* incident showed, a subsea release of hydrocarbons at a high flow rate has the potential to disperse and suspend oil droplets (chemically dispersed or otherwise) within the water column and to induce large patches of sheen and oil on the surface. These dispersed hydrocarbons may adsorb onto marine detritus (marine snow) or may be mixed with drilling mud and deposited near the source. Mitigation efforts such as burning may introduce hydrocarbon byproducts into the marine environment, which would be distributed by surface currents. The acute and chronic sublethal effects of these dilute suspended “plumes” are not well understood and require future research efforts.

Large amounts of oil put into offshore water may alter the chemistry of the sea with unforeseeable results. The VOCs, including benzene, can have acutely toxic effects. The components of crude oil that are water soluble are more available than some of the heavier components to exert a toxic effect on marine life. The PAHs are present in crude oil and include carcinogenic compounds and compounds that pose various risks to marine organisms and possibly to the higher trophic level species, including humans that feed on these organisms. The PAHs are also persistent in the environment. Impacts from the subsequent extended oil spill on offshore water quality are discussed further in Section 3.2.1.2.

Release of Natural Gas (Methane) into the Water Column

A catastrophic blowout could release natural gas into the water column; the amount of gas released is dependent upon the water depth, the natural gas content of the formation being drilled, and its pressure. Methane is the primary component of natural gas (NaturalGas.org, 2010). Methane may stay in the marine environment for long periods of time (Patin, 1999; p. 237), as methane is highly soluble in seawater at the high pressures and cold temperatures found in deepwater environments (NRC, 2003; p. 108). However, methane diffusing through the water column would likely be oxidized in the aerobic zone

and would rarely reach the air-water interface (Mechalas, 1974; p. 23). In addition to methane, natural gas contains smaller percentages of other gases such as ethane and propane. It may also contain VOCs (including benzene, toluene, ethylbenzene, and xylene) and H_2S, which have individual toxic characteristics. Methane and other natural gas constituents are carbon sources, and their introduction into the marine environment could result in reducing the dissolved oxygen levels due to microbial degradation of the methane potentially creating hypoxic or “dead” zones. Depletion of dissolved oxygen in the Gulf of Mexico due to the release of natural gas from the Macondo well (*Deepwater Horizon* incident) is currently being examined as a result of the *Deepwater Horizon* incident (Schenkman, 2010). Unfortunately, little is known about methane toxicity in the marine environment, but there is concern as to how methane in the water column might affect fish (see Section 3.2.2.2).

2.2.2. Biological Resources

Impacts during the initial event would be limited to environmental resources in the immediate vicinity of the blowout as described below.

2.2.2.1. Marine and Migratory Birds

Many migratory birds use offshore platforms or rigs as rest sites during migration (Russell, 2005). In addition, seabirds are attracted to offshore platforms and rigs (Tasker et al., 1986; Weise et al., 2001). The numbers of birds present at a platform or rig are greater when platforms or rigs are closer to shore during drilling operations (Baird, 1990). Birds resting on the drilling rig or platform during a catastrophic blowout are likely to be killed by an explosion. While it is assumed that most birds in trans-Gulf migration would likely avoid the fire and smoke plume during the day, it is conceivable that the light from the fire could interfere with nocturnal migration, especially during poor visibility conditions. It has been documented that seabirds are attracted to natural gas flares at rigs and platforms (Russell, 2005; Wiese et al., 2001); therefore, additional bird fatalities could result from the fire following the blowout. Though different species migrate throughout the year, the largest number of species migrates from March through November. A blowout during this time would cause a greater number of bird fatalities. While the number and species of birds killed depends on the blowout location and time of year, these initial fatalities would likely not result in population-level impacts for species present at the time of the blowout and resulting fire (Russell, 2005: Table 6.12).

2.2.2.2. Fish, Fisheries, and Essential Fish Habitat

Depending on the type of blowout and the proximity of marine life to it (Table 1), an eruption of gases and fluids may generate not only a toxic effect but also pressure waves and noise significant enough to injure or kill local biota. Within a few thousand meters of the blowout, resuspended sediments may clog fish gills and interfere with respiration. Settlement of resuspended sediments may, in turn, smother invertebrates or interfere with their respiration. Offshore benthic habitats that support fisheries could also be impacted, as discussed below.

2.2.2.3. Marine Mammals

Depending on the type of blowout, the pressure waves and noise generated by the eruption of gases and fluids would likely be significant enough to harass, injure, or kill marine mammals, depending on the proximity of the animal to the blowout. A high concentration of response vessels could result in harassment or displacement of individuals and could place marine mammals at a greater risk of vessel collisions, which would likely cause fatal injuries.

In addition to the above, the presence of hydrocarbons and other materials generated from a spill through which marine mammals swim may result in direct harm by clogging blowholes, etc.

2.2.2.4. Sea Turtles

Five species of sea turtles are found in the waters of the Gulf of Mexico: green, leatherback, hawksbill, Kemp’s ridley, and loggerhead. All species are protected under the Endangered Species Act

(ESA), and all are listed as endangered except the loggerhead turtle, which is listed as threatened. Depending on the type of blowout (Table 1), an eruption of gases and fluids may generate significant pressure waves and noise that may harass, injure, or kill sea turtles, depending on their proximity to the accident. A high concentration of response vessels could place sea turtles at a greater risk of fatal injuries from vessel collisions.

Further, mitigation by burning puts turtles at risk because they tend to be gathered up in the corralling process necessary to concentrate the oil in preparation for the burning. Trained observers should be required during any mitigation efforts that include burning.

2.2.2.5. Offshore Benthic Habitats

Gulf of Mexico benthic resources are divided into shelf habitats and deepwater habitats. Shelf habitats of the Gulf of Mexico include soft-bottom habitats (sandy and muddy substrate) and hard-bottom habitats (rock or salt outcroppings that provide habitat for encrusting organisms). Deepwater benthic communities of the Gulf of Mexico include soft-bottom, coral, and chemosynthetic habitats. The impacts to these benthic communities depend on the location and the type of catastrophic blowout that occurs.

Introduction

Sediment disturbance as a result of the blowout above the seafloor would not occur. A catastrophic blowout that occurs above the seabed (at the rig, along the riser between the seafloor and sea surface, or through leak paths on the BOP/wellhead) would result in released oil rising to the sea surface. However, if the leak is deep in the water column and the oil is ejected under pressure, oil droplets may become entrained deep in the water column. The upward movement of the oil may be reduced if methane in the oil is dissolved at the high underwater pressures, reducing the oil's buoyancy (Adcroft et al., 2010). The large oil droplets will rise to the sea surface, but the smaller droplets, formed by vigorous turbulence in the plume or the injection of dispersants, may remain neutrally buoyant in the water column, creating a subsurface plume (Adcroft et al., 2010). Oil droplets less than 100 micrometers in diameter may remain in the water column for several months (JAG, 2010) where they will not be in contact with benthic habitats; similarly, large oil drops on the sea surface will not be in contact with benthos. However, oil in the water column or at the sea surface may sometimes sink, contact benthos, and have impacts, as discussed below.

As discussed below, a catastrophic blowout outside the well casing and below the seafloor or at the seafloor water interface could resuspend large quantities of bottom sediments and create a large crater, destroying many organisms within a few hundred meters of the wellhead. Some of the sediment could travel up to a few thousand meters before redeposition, negatively impacting a localized area of benthic communities.

The use of subsea dispersants would increase the exposure of offshore benthic habitats to dispersed oil droplets in the water column, as well as the chemicals used in the dispersants. The use of subsea dispersants is not likely to occur for seafloor blowouts outside the well casing.

Soft-Bottom Shelf Habitats

The vast majority of the Gulf of Mexico seabed is comprised of soft sediments. Microbes to metazoans (e.g., polychaete worms and crabs) inhabit the soft-bottom benthos, many forming the base of the food chain for several species. When soft-bottom infaunal communities are physically impacted by a blowout (either lost to the crater formation or smothered by sediment), recolonization by populations from neighboring soft-bottom substrate is expected within a relatively short period of time. Many of the organisms on soft bottoms live within the sediment and have the ability to migrate upward in response to burial by sedimentation. A blowout that occurs outside the well casing can rapidly deposit 30 cm (12 inches) or more of sediment within a few hundred meters and may smother much of the soft-bottom community in a localized area. In situations where soft-bottom infaunal communities are negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms, in a matter of days for bacteria, and probably less than 1 year for most macrofauna and megafauna species. Recolonization could take longer for areas affected by direct contact of concentrated oil. Initial repopulation from nearby stocks of pioneering species, such as tube-dwelling polychaetes or oligochaetes, may begin with the next

recruitment event (Rhodes and Germano, 1982). Full recovery would follow as later stages of successional communities overtake the pioneering species (Rhodes and Germano, 1982). The time it takes to reach a climax community may vary depending on the species and degree of impact. Full benthic community recovery may take years to decades if the benthic habitat is heavily oiled (Gesteira and Dauvin, 2000; Sanders et al., 1980; Conan, 1982). A slow recovery rate will result in a community with reduced biological diversity and possibly a lesser food value for predatory species.

Hard-Bottom Shelf Habitats

The Gulf of Mexico shelf has several hard-bottom features upon which encrusting and epibenthic organisms attach. Though there are varying degrees of relief on the hard bottom, the impacts from a catastrophic blowout are similar for the banks of varying relief because similar organisms occur on these features. Thus, they are discussed as a single grouping under "hard-bottom communities," with references to specific communities where impacts may differ.

Topographic features are isolated areas of moderate to high relief that provide habitat for hard-bottom communities of high biomass and moderate diversity. These features provide shelter and food for large numbers of commercially and recreationally important fish. There are 37 named topographic features in the Gulf of Mexico with specific BOEMRE protections, including the Flower Garden Banks National Marine Sanctuary. The BOEMRE has created "No Activity Zones" around topographic features in order to protect these habitats from disruption due to oil and gas activities. A "No Activity Zone" is a protective perimeter drawn around each feature that is associated with a specific isobath (depth contour) surrounding the feature in which structures, drilling rigs, pipelines, and anchoring are not allowed. These "No Activity Zones" are areas where activity is prohibited based on BOEMRE policy. Notice to Lessees and Operators (NTL) 2009-G39 recommends that drilling should not occur within 152 meters ([m]; 500 ft) of a "No Activity Zone" of a topographic feature.

The northeastern portion of the central Gulf of Mexico is a region of low to moderate relief known as the "Pinnacle Trend" at the outer edge of the Mississippi-Alabama shelf between the Mississippi River and De Soto Canyon. These outcrops provide hard substrate for sessile invertebrate attachment that attracts fish. The NTL 2009-G39 recommends that no bottom-disturbing activities occur within 30 m (100 ft) of any hard bottoms/pinnacles with a relief of 8 ft or greater.

Potentially sensitive biological features are features that have moderate to high relief (8 feet or higher), provide hard surface for sessile invertebrates, attract fish, but are not located within Pinnacle-designated blocks or the "No Activity Zone" of topographic features. No bottom-disturbing activities that may cause impact to these features are permitted.

Impacts that occur to hard-bottom shelf habitats as a result of a blowout would depend on the type of blowout, distance from the blowout, relief of the biological feature, and surrounding physical characteristics of the environment (e.g., turbidity). The NTL 2009-G39 recommends the use of buffers to prevent blowouts in the immediate vicinity of a hard-bottom habitat or its associated biota. Much of the oil released from a blowout would rise to the sea surface, therefore minimizing the impact to benthic communities by direct oil exposure. However, small droplets of oil that are entrained in the water column for extended periods of time may migrate into "No Activity Zones." Although these small oil droplets will not sink themselves, they may attach to suspended particles in the water column and then be deposited on the seafloor (McAuliffe et al., 1975). These long-term impacts, such as reduced recruitment success, reduced growth, and reduced coral cover, as a result of impaired recruitment, are discussed in Section 3.2.2.6. Also, if the blowout were to occur beneath the seabed, suspension and subsequent deposition of disturbed sediment may smother localized areas of benthic communities, possibly including organisms within No Activity Zones or other hard-bottom substrate.

Benthic communities on a hard-bottom feature exposed to large amounts of resuspended and deposited sediments following a catastrophic, subsurface blowout could be subject to sediment suffocation, exposure to resuspended toxic contaminants, and reduced light availability. Impacts to corals as a result of sedimentation would vary based on coral species, the height to which the coral grows, degree of sedimentation, length of exposure, burial depth, and the coral's ability to clear the sediment. Impacts may range from sublethal effects such as reduced growth, alteration in form, and reduced recruitment and productivity to slower growth to death (Rogers, 1990).

The initial blowout impact would be greatest to communities located in clear waters that experience heavy sedimentation. Reef-building corals are sensitive to turbidity and may be killed by heavy sedimentation (Rogers, 1990; Rice and Hunter, 1992). However, it is unlikely that reef-building corals would experience heavy sedimentation as a result of a blowout because drilling activity would not be allowed near sensitive organisms in the "No Activity Zones," based on the NTL 2009-G39. The most sensitive organisms are also typically elevated above soft sediments, making them less likely to be buried. It is possible, however, for potentially sensitive biological features outside of "No Activity Zones" or Pinnacle-designated blocks to experience some turbidity or sedimentation impacts. Corals may also experience discoloration or bleaching as a result of sediment exposure, although recovery from such exposure may occur within 1 month (Wesseling et al., 1999).

Initial impacts would be much less extreme in a turbid environment (Rogers, 1990). For example, the Pinnacle Trend community exists in a relatively turbid environment, starting just 65 kilometers ([k]; 40 mi) east of the mouth of the Mississippi River and trending to the northeast. Sediment from a blowout, if it occurred nearby, may have a reduced impact on these communities compared with an open-water reef community, as these organisms are more tolerant of suspended sediment (Gittings et al., 1992). Many of the organisms that predominate in this community also grow tall enough to withstand the sedimentation that results from their turbid environment or they have flexible structures that enable the passive removal of sediments (Gittings et al., 1992).

A portion or the entire rig may sink to the seafloor as a result of a blowout. The benthic communities (hard- or soft-bottom communities) on the seafloor upon which the rig settles would be destroyed or smothered. A settling rig may suspend sediments, which may smother nearby benthic communities as the sediment is redeposited on the seafloor. The habitats beneath the rig may be permanently lost; however, the rig itself may become an artificial reef upon which epibenthic organisms may settle. The surrounding benthic communities that were smothered by sediment would repopulate from nearby stocks through spawning recruitment and immigration.

Deepwater Habitats

The effects of a catastrophic blowout event on Gulf of Mexico benthic resources in deep water (>1,000 ft; 300 m) are similar to those on the shelf communities. The main factors are the type of blowout and the proximity to the habitat. Known deepwater communities include soft bottoms and two types of hard-bottom communities: chemosynthetic communities and deep coral communities. Many of the organisms on soft bottoms live within the sediment and have the ability to migrate upward in response to burial by sedimentation. A blowout that occurs outside the well casing can rapidly deposit 30 cm (12 inches) or more of sediment within a few hundred meters and may smother much of the soft-bottom community in a localized area. In situations where soft-bottom infaunal communities are negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms, in a matter of days for bacteria, and probably less than 1 year for most macrofauna and megafauna species. Recolonization could take longer for areas affected by direct contact of concentrated oil.

BOEMRE restrictions applicable to work near deepwater hard-bottom areas (as described in NTL 2009-G40) would prevent direct negative effects from a seafloor blowout. The established policy prohibits location of wells within 2,000 ft (610 m) of a suspected hard-bottom habitat. Geophysical analyses have achieved a high degree of reliability in detecting the potential presence of hard-bottom communities in the Gulf of Mexico. In rare instances, the subtle geophysical signatures of hydrocarbon seepage, conducive to the development of a chemosynthetic deepwater community development at the seabed that are a probable indicator of a community are not discovered during routine environmental analysis. Therefore, it is possible that a well could be drilled close enough for a hard-bottom community to be damaged in the event of a catastrophic blowout.

Blowouts at points above the seafloor (in the riser or on the drill platform) would have little immediate effect on deepwater seafloor communities unless the structure sinks and physically impacts the seafloor. If a structure sank directly on a hard-bottom community, at least 2,000 ft (610 m) from the well, organisms could be crushed and smothered.

2.2.3. Socioeconomic Resources

2.2.3.1. Offshore Archaeological Resources

BOEMRE protects all known, discovered, and potentially historic and prehistoric archaeological resources on the OCS by requiring appropriate avoidance criteria as well as directives to investigate these resources.

Onshore archaeological resources, prehistoric and historic sites, would not be immediately impacted during the initial phase of a catastrophic blowout because the distance of a blowout site from shore is at least 3 nautical miles. However, offshore catastrophic blowouts, when compared with spills of lesser magnitude, may initially impact multiple archaeological resources. Resources adjacent to a catastrophic blowout could be damaged by the high volume of escaping gas, buried by large amounts of dispersed sediments, crushed by the sinking of the rig or platform, destroyed during emergency relief well drilling, or contaminated by the hydrocarbons.

Based on historical information, over 2,100 potential shipwreck locations have been identified in the Gulf of Mexico OCS (USDOI, MMS, 2007). This number is a conservative estimate and is heavily weighted toward post-19th century, near-shore shipwrecks, where historic records documenting the loss of the vessels were generated more consistently. Of the 2,100 recorded wrecks, only 233 records were determined to have associated spatial data possessing sufficient accuracy for BOEMRE's needs.

The inadequacy of data related to these historic ship losses creates uncertainty in determining how many shipwrecks might be located near existing or planned oil and gas wells. If undiscovered shipwrecks are adjacent to a catastrophic blowout, the potential for impacting these nonrenewable resources is high. However, the potential of a well being drilled close enough to damage or bury a known prehistoric or historic resource, such as a shipwreck, is low when archaeological surveys are required prior to any exploration or development activities.

2.2.3.2. Commercial Fishing

The initial explosion and fire could endanger commercial fishermen in the immediate vicinity of the blowout. Although commercial fishing vessels in the area would likely aid in initial search-and-rescue operations, the subsequent fire could burn for over a month, during which time commercial vessels would be expected to avoid the area so as to not interfere with response activities. This could impact the livelihood and income of these commercial fishermen.

2.2.3.3. Recreational Resources and Fishing

A substantial amount of recreational activity is associated in the immediate area around shallow water oil and gas structures because these structures function as artificial reefs, promote coral growth, and attract fish. About 20 percent of the recreational fishing activity and 90 percent of the recreational diving activity in the Gulf of Mexico occurs within 300 feet of oil and gas structures (Hiett and Milon, 2002). Therefore, an explosion and fire within 100 miles of shore could endanger recreational fishermen and divers in the immediate vicinity of the blowout, especially if the blowout is located between water depths of 100 and 200 feet. Recreational vessels in the area would likely aid in initial search-and-rescue operations but would also be in danger during the explosion and subsequent fire. The subsequent fire could burn for more than a month, during which recreational vessels would be expected to avoid the area and not interfere with response activities. This will impact the income of recreational fishing and diving businesses. Also, if the fire and smoke is visible from recreational beaches, their recreational use may be impacted.

2.2.3.4. Human Resources, Land Use, and Environmental Justice

Fatalities and serious injuries would likely occur during the initial explosion and/or fire. Due to the large number of people (>100) working on a deepwater drilling rig or platform, dozens of fatalities and serious injuries could occur.

With the explosion (>3 nautical miles) from the shore and the likelihood that the resulting fire will burn for a short duration, the initial fire and/or explosion is not expected to impact land use,

demographics, or economics, although some recreational beach use may be impacted (Section 2.2.2.3). Thus, the initial fire and explosion should not disproportionately affect low-income persons or minorities, and therefore, will not raise environmental justice concerns.

3. OFFSHORE SPILL (PHASE 2)

3.1. IMPACT-PRODUCING FACTORS AND SCENARIO

Phase 2 of the analysis focuses on the spill and response in Federal and State offshore waters.

3.1.1. Duration of Spill

The duration of the offshore spill from a blowout depends on time needed for intervention and time the remaining oil persists offshore. If a blowout occurs and the damaged surface facilities preclude well reentry operations, a relief well may be needed to regain control. The time required to drill the relief well depends on the complexity of the intervention, the location of a suitable rig, the type of operation that must be terminated to release the rig (e.g., casing may need to be run before releasing the rig), and problems mobilizing personnel and equipment to the location. A blown-out well may also be successfully capped prior to completion of relief wells, as occurred in the *Deepwater Horizon* incident. Assuming the duration of previous spills including the *Deepwater Horizon* and the type of oil and water temperatures found in the Gulf of Mexico, the majority of visibly spilled oil on the surface of the water would not persist more than 30 days after the oil flow stopped (Inter-agency, 2010a).

3.1.1.1. Shallow Water

If a blowout occurs in shallow water the entire intervention effort including drilling relief wells could take 1 to 3 months. This includes 1-3 weeks to transport the drilling rig to the well site. Spilled surface oil is not expected to persist more than 1 month after the flow is stopped. Therefore, the estimated spill duration resulting from a shallow water blowout in is 2-4 months.

3.1.1.2. Deepwater

If a blowout occurs in deepwater, the entire intervention effort including drilling relief wells could take 3 to 4 months. (USDOI, MMS, 2000; Regg, 2000). This includes 2-4 weeks to transport the drilling rig to the well site. Spilled surface oil is not expected to persist more than 1 month after the flow is stopped. Therefore, the estimated spill duration from a deep water blowout is 4-5 months.

3.1.2. Area of Spill

When oil reaches the sea surface, it spreads. The speed and extent of spreading depends on the type and volume that is spilled. However, a catastrophic spill would likely spread hundreds of square miles. Also, the oil slick may break into several smaller slicks, depending on local wind patterns that drive the surface currents in the spill area.

3.1.3. Volume of Spill

For this analysis, a higher flow rate is assumed for a blowout in deep water for the following reasons: After 50 years of Gulf of Mexico development most, if not all, of the largest shallow water prospects have been developed. As a result, reservoir pressures in shallow water are generally reduced. Although under certain conditions oil may be present with the natural gas, deeper shelf wells target natural gas. Also, because deepwater development is costly, only larger prospects with higher flow rates are currently targeted for exploration.

3.1.3.1. Shallow Water

For this analysis, an uncontrolled flow rate of 30,000 barrels per day is assumed for a catastrophic blowout in shallow water. This assumption is based upon the results of well tests in shallow water (see Section 3.1.3 above) and the maximum flow rate from the 1979 *Ixtoc* blowout, which occurred in shallow water. Using this flow rate, the total volume of oil spilled from a catastrophic blowout in shallow water is estimated at 900,000 to 3 million barrels for a spill lasting 1-3 months. In addition to the flow rate, it is assumed that any remaining diesel fuel from a sunken drilling rig would also leak.

3.1.3.2. Deep Water

For the purposes of this analysis, an uncontrolled flow rate of 30,000-60,000 barrels per day is assumed for a catastrophic blowout in deep water. This flow rate is based on the assumption in Section 3.1.3 above, well test results, and the maximum expected flow rate of the 2010 *Deepwater Horizon* blowout, which occurred in deep water. Therefore, total volume of oil spilled is estimated to be 2.7-7.2 million barrels over 3-4 months. In addition, deepwater drilling rigs hold a large amount of diesel fuel (10,000-20,000 barrels). Therefore, it is assumed that any remaining diesel fuel from a sunken drilling rig would also leak and add to the spill.

3.1.4. Oil in the Environment: Properties and Persistence

The fate of oil in the environment depends on many factors, such as the source and composition of the oil, as well as its persistence (NRC, 2003). Persistence can be defined and measured in different ways (Davis et al., 2004), but the National Research Council (NRC) generally defines persistence as how long oil remains in the environment (NRC, 2003; p. 89). Once oil enters the environment, it begins to change through physical, chemical, and biological weathering processes (NRC, 2003). These processes may interact and affect the properties and persistence of the oil through

- evaporation (volatilization),
- emulsification (the formation of a mousse),
- dissolution,
- biodegradation
- oxidation, and
- transport processes (NRC, 2003; Scholz et al., 1999).

Horizontal transport takes place via spreading, advection, dispersion, and entrainment while vertical transport takes place via dispersion, entrainment, Langmuir circulation, sinking, overwashing, partitioning, and sedimentation (NRC, 2003). The persistence of an oil slick is influenced by the effectiveness of oil-spill response efforts and affects the resources needed for oil recovery (Davis et al., 2004). The persistence of an oil slick may also affect the severity of environmental impacts as a result of the spilled oil.

Crude oils are not a single chemical, but instead are complex mixtures with varied compositions. Thus, the behavior of the oil and the risk the oil poses to natural resources depends on the composition of the specific oil encountered (Michel, 1992). Generally, oils can be divided into three groups of compounds: (1) light-weight, (2) medium-weight, and (3) heavy-weight components. On average, these groups are characterized as outlined below in Table 2.

Table 2

Properties and Persistence by Oil Component Group

Properties and Persistence	Light-weight	Medium-weight	Heavy-weight
Hydrocarbon compounds	Up to 10 carbon atoms	10-22 carbon atoms	>20 carbon atoms
API º	>31.1º	31.1º-22.3 º	<22.3 º
Evaporation rate	Rapid (within 1 day) and complete	Up to several days; not complete at ambient temperatures	Negligible
Solubility in water	High	Low (at most a few mg/L)	Negligible
Acute toxicity	High due to monoaromatic hydrocarbons (BTEX)	Moderate due to diaromatic hydrocarbons (naphthalenes—2 ring PAH's)	Low except due to smothering (i.e., heavier oils may sink)
Chronic toxicity	None, does not persist due to evaporation	PAH components (e.g., naphthalenes—2 ring PAH's)	PAH components (e.g., phenanthrene, anthracene—3 ring PAH's)
Bioaccumulation potential	None, does not persist due to evaporation	Moderate	Low, may bioaccumulate through sediment sorption
Compositional majority	Alkanes and cycloalkanes	Alkanes that are readily degraded (specify, as done for others)	Waxes, asphaltenes, and polar compounds (not significantly bioavailable or toxic)
Persistence	Low due to evaporation	Alkanes readily degrade, but the diaromatic hydrocarbons are more persistent	High; very low degradation rates and can persist in sediments as tarballs or asphalt pavements

Sources: Michel, 1992; Canadian Center for Energy Information, 2010.

Of the oil reservoirs sampled in the Gulf of Mexico OCS, the majority fall within the light-weight category, while less than one quarter are considered medium-weight and a small portion are considered heavy-weight. Oil with an API gravity of 10.0 or less would sink and has not been encountered in the Gulf of Mexico OCS and, therefore, it is not analyzed in this paper (USDOI, BOEMRE, 2010c).

Heavy-weight oil may persist in the environment longer than the other two types of oil, but the medium-weight components within oil present the greatest risks to organisms because, with the exception of the alkanes, these medium-weight components are persistent, bioavailable, and toxic (Michel, 1992).

Previous studies (e.g., Johansen et al., 2001) supported the assumption that most, if not all, released oil would reach the surface of the water column. However, data and observations from the *Deepwater Horizon* incident challenge that assumption. While analyses are in their preliminary stages, it appears that measurable amounts of hydrocarbons (dispersed or otherwise) are being detected in the water column as subsurface "plumes" and on the seafloor in the vicinity of the release. While not all of these hydrocarbons have been definitively traced back to releases from the Macondo well (*Deepwater Horizon* incident), these early measurements and results warrant a reassessment of previous assumptions of the ultimate fate of hydrocarbons from unintended subsurface releases.

3.1.5. Release of Natural Gas

The quality and quantity of components in natural gas vary widely by the field, reservoir, or location from which the natural gas is produced. Although there is not a "typical" makeup of natural gas, it is primarily composed of methane (NaturalGas.org, 2010).

3.1.6. Offshore Cleanup Activities

As demonstrated by the *Ixtoc* and *Deepwater Horizon* spill responses, a large-scale response effort is certain to follow a catastrophic blowout. The number of vessels and responders would increase exponentially as the spill continued.

3.1.6.1. Shallow Water

Within the first week of an oil spill originating in shallow water, 25 vessels are estimated to respond, which would steadily increase to over 3,000 by the end of the spill. This includes about 25 skimmers in the vicinity of the well at a time. In addition, recovered oil may be barged to shore from recovery vessels.

Within the first week, over 500 responders are estimated to be deployed to a spill originating in shallow water, which would steadily increase up to 25,000 before the well is capped or killed within 2-4 months.

Response to an oil spill in shallow water is expected to involve over 10,000 feet of boom within the first week and would steadily increase up to 5 million feet (1,000 miles) for use offshore and nearshore, the amount dependent upon the location of the potentially impacted shoreline, environmental considerations, and agreed upon protection strategies involving the local potentially impacted communities.

Up to 25 planes and 50 helicopters are estimated to respond per day by the end of a shallow-water spill.

Along the Gulf Coast, dispersants are have been preapproved for use greater than 3 nautical miles from shore and in water depths greater than 33 feet, with the exception of Florida where the water depth must be 65 feet (USCG, 2010). However, the USEPA is presently examining these preapprovals and restrictions are anticipated regarding the future use of dispersants for ongoing spills as a result. Changes to the dispersant use preapprovals would be expected to limit this use in the future. Under pre-existing preapprovals it is estimated that up to a total of 35,000 barrels of dispersant would be used.[1] Aerial dispersants would likely be applied from airplanes as a mist, which settles on the oil on the water's surface. In addition to dispersants, controlled burns may also occur.

3.1.6.2. Deep Water

Within the first week of oil spill originating in deep water, 50 vessels are estimated to respond, which would steadily increase to over 7,000 by the end of the spill. This includes about 25 skimmers in the vicinity of the well at a time. In addition, recovered oil may be shuttle tankered to shore from recovery vessels.

For an oil spill in deep water, over 1,000 responders are estimated to be deployed within the first week, which would steadily increase up to 50,000 before capping or killing the well within 4-5 months.

Over 20,000 feet of boom is estimated to be deployed within the first week of a deepwater spill, which would steadily increase up to 11 million feet (2,100 miles) offshore and nearshore, the amount dependent upon the location of the potentially impacted shoreline, environmental considerations, and agreed upon protection strategies involving the local potentially impacted communities.

Up to 50 planes and 100 helicopters are estimated to respond per day by the end of a deepwater spill.

With the exception of special Federal management areas or designated exclusion areas, dispersants have been preapproved in the vicinity of a deepwater blowout (USCG, 2010). However, the USEPA is presently examining these preapprovals and restrictions are anticipated regarding the future use of dispersants as a result. Under pre-existing preapprovals it is estimated that up to 50,000 barrels of dispersant would could be applied (2/3 on the water surface and 1/3 subsurface, if possible). Changes to the dispersant use preapprovals would be expected to limit this use. No preapproval presently exists for the use of subsea dispersants and approval must be obtained before each use of this technology. The use of subsea dispersants depends on the location of the blowout, as discussed in Table 1. Aerial dispersants are applied from airplanes as a mist, which settles on the oil on the water's surface. In addition to

[1] At the IXTOC-I Well Blowout in 1979, between 1 million and 2.5 million gallons of mostly Corexit dispersant products were applied over a 5-month period on the oil discharge. However, this scenario assumes a spill from a blowout in shallow water would last up to 3 months.

dispersants, it is estimated that 5-10 controlled burns would be conducted per day in suitable weather. About 500 burns in all would remove 5-10 percent of the oil.

3.1.6.3. Vessel Decontamination Stations

To avoid contaminating inland waterways, multiple vessel decontamination stations may be established offshore in Federal and State waters. Vessels responding to the spill and commercial and recreational vessels passing through the spill would anchor, awaiting inspection. If decontamination is required, work boats would use fire hoses to clean oil from the sides of the vessels. This could result in some oiling of otherwise uncontaminated waters. While these anchorage areas would be surveyed for buried pipelines that could be ruptured by ship anchors, they may not be surveyed adequately for benthic communities or archaeological sites. Therefore, some damage to benthic communities or archaeological sites may occur due to vessel decontamination activities associated with an oil spill in deep water (Alabama State Port Authority, 2010; Office of the Governor, State of Florida, 2010; Nodar, 2010; Unified Incident Command, 2010a-c; USDOC, NOAA, 2010a; USEPA, 2010a).

3.1.7. Severe Weather

A hurricane could accelerate biodegradation, increase the area affected by the spill, and/or slow the response effort. The Atlantic hurricane season runs from June 1st through November 30th, peaking in September. In an average Atlantic season, there are eleven named storms, six hurricanes, and two Category 3 or higher storms (USDOC, NOAA, National Weather Service, 2010a). As a result of a hurricane, high winds and seas would mix and “weather” the oil from an oil spill. This can help accelerate the biodegradation process (USDOC, NOAA, National Weather Service, 2010b). The high winds may distribute oil over a wider area (USDOC, NOAA, National Weather Center, 2010b). In the event of a hurricane, vessels would evacuate the area, delaying response efforts, including the drilling of relief wells and any well capping or collection efforts.

3.2. MOST LIKELY AND MOST SIGNIFICANT IMPACTS

The most recent EISs prepared by BOEMRE for oil and gas lease sales in the Gulf of Mexico identify in detail the potential impacts from reasonably foreseeable oil spills (USDOI, MMS, 2007 and 2008). In addition to the impacts described in those documents, the most likely and most significant impacts due to the magnitude of shoreline oil as a result of a catastrophic spill are described below.

3.2.1. Physical Resources

3.2.1.1. Air Quality

In the Gulf of Mexico, evaporation from the oil spill would result in concentrations of volatile organic compounds (VOCs) in the atmosphere, including chemicals that are classified as being hazardous. The VOC concentrations would occur anywhere where there is an oil slick, but would be highest at the source of the spill because the rate of evaporation depends on the volume of oil present at the surface. VOC concentrations would and decreases with distance as the layer of oil gets thinner. The lighter fractions of VOC’s would be most abundant in the immediate vicinity of the spill site. The heavier compounds would be emitted over a longer period of time and over a larger area. Some of the compounds emitted could be hazardous to workers in close vicinity of the spill site. The hazard to workers can be reduced by monitoring and using protective gear, including respirators. During the *Deepwater Horizon* incident, air samples collected by individual offshore workers by British Petroleum (BP), Occupational Safety and Health Administration (OSHA), and U.S. Coast Guard showed levels of benzene, toluene, ethylbenzene, and xylene that were mostly under detection levels. All samples had concentrations below the OSHA Occupational Permissible Exposure Limits (PELs) and the more stringent ACGIH (American Conference of Governmental Industrial Hygienists) Threshold Limit Values (TLVs) (U.S. Department of Labor, OSHA, 2010a).

The VOC emissions that result from the evaporation of oil contribute to the formation of particulate matter ($PM_{2.5}$) in the atmosphere. In addition, VOCs could cause an increase in ozone levels, especially if

the release were to occur on a hot, sunny day with sufficient concentrations of NO_x present in the lower atmosphere. However, due to the distance from shore, the oil slick would not normally have any effects on onshore ozone concentrations.

It is assumed that response efforts would include hundreds of in-situ or controlled burns, which would remove an estimated 5-10 percent of the volume of oil spilled. This could be as much as 720,000 barrels of oil for a spill of 60,000 barrels per day for 120 days. In-situ burning would result in ambient concentrations of CO, NO_x, SO_2, PM_{10}, and $PM_{2.5}$ very near the site of the burn and would generate a plume of black smoke. The levels of $PM_{2.5}$ could be a hazard to personnel working in the area, but this could be effectively mitigated through monitoring and relocating vessels to avoid areas of highest concentrations. In an experiment of an in-situ burn off Newfoundland, it was found that CO, SO_2, and NO_2 were measured only at background levels and were frequently below detection levels (Fingas et al., 1995). Limited amounts of formaldehyde and acetaldehyde were measured, but concentrations were close to background levels. Measured values of dioxins and dibenzofurans were at background levels. Measurements of PAH in the crude oil, the residues, and the air indicated that the PAH in the crude oil are largely destroyed during combustion (Fingas et al, 1995).

While containment operations may be successful in capturing some of the escaping oil and gas, recovery vessels may not be capable of storing the crude oil or may not have sufficient storage capacity. In this case, excess oil would be burned; captured gas cannot be stored or piped to shore so it would be flared. For example, in the *Deepwater Horizon* incident, gas was flared at the rate of 100-200 million cubic feet per day and oil burned at the rate of 10,000-15,000 barrels per day. The estimated NO_x emissions are about 13 tons per day. The SO_2 emissions would be dependent on the sulfur content of the crude oil. For crude oil with a sulfur content of 0.5 percent, the estimated SO_2 emissions are about 16 tons per day. Particulate matter in the plume would also affect visibility. Flaring or burning activities upwind of a PSD Class I area, e.g., the Breton National Wilderness Area, could be adversely affected due to SO_2 concentrations and reduced visibility.

3.2.1.2. Offshore Water Quality

The water offshore of the Gulf's coasts can be divided into two regions: the continental shelf and slope (<1,000 ft; 305 m) and deep water (>1,000 ft; 305 m). Waters on the continental shelf and slope are heavily influenced by the Mississippi and Atchafalaya Rivers, the primary sources of freshwater, sediment, nutrients, and pollutants from a huge drainage basin encompassing 55 percent of the continental U.S. (Murray, 1998). Lower salinities are characteristic nearshore where freshwater from the rivers mix with Gulf waters. The presence or extent of a nepheloid layer, a body of suspended sediment at the sea bottom (Kennett, 1982; p. 524), affects water quality on the shelf and slope. Deep waters east of the Mississippi River are affected by the Loop Current and associated warm-core (anti-cyclonic) eddies, which flush the area with clear, low-nutrient water (Muller-Karger et al., 2001). However, cold-core cyclonic eddies (counter-clockwise rotating) also form at the edge of the Loop Current and are associated with upwelling and nutrient-rich, high-productivity waters, although the extent of this flushing can vary seasonally.

While response efforts would decrease the fraction of oil remaining in Gulf waters, significant amounts of oil would remain (Inter-agency, 2010a). Natural processes will physically, chemically, and biologically aid the degradation of oil (NRC, 2003). The physical processes involved include evaporation, emulsification, and dissolution, while the primary chemical and biological degradation processes include photooxidation and biodegradation (i.e., microbial oxidation). Water quality would not only be impacted by the oil, gas, and their respective components but also to some degree from cleanup and mitigation efforts, such as from increased vessel traffic and the addition of dispersants and methanol to the marine environment.

In the case of a catastrophic subsea blowout in deep water, it is assumed that large quantities of subsea dispersants would be used. As a result, clouds or plumes of dispersed oil may occur near the blowout site. Reports thus far from the *Deepwater Horizon* incident have found such plumes and have shown that the concentrations of these clouds decrease to undetectable levels within a few miles of the source (USDOC, NOAA, 2010b). Additional reporting in the coming months will enhance the understanding of the effects of subsurface plumes. Dissolved oxygen levels are a concern with any release of a carbon source, and these levels became a particular concern during the *Deepwater Horizon* incident,

since dispersants were used in deep waters for the first time. Thus, the U.S. Environmental Protection Agency (USEPA) required monitoring protocols in order to use subsea dispersants (USDOC, NOAA, 2010c). In areas where plumes of dispersed oil were previously found, dissolved oxygen levels decreased by about 20 percent from long-term average values in the Gulf of Mexico; however, scientists reported that these levels have stabilized and are not low enough to be considered hypoxic (USDOC, NOAA, 2010d). The temporary decrease in oxygen content has been attributed to microbial degradation of the oil. Over time, as the oil continues to be degraded and diffuses, hypoxia becomes less of a concern. As reported for the *Deepwater Horizon* incident, dissolved oxygen levels would likely remain above levels of immediate concern, but there would still be a need to monitor dissolved oxygen levels over time.

Toxicity of dispersed oil in the environment would depend on many factors, including the effectiveness of the dispersion, temperature, salinity, degree of weathering, type of dispersant, and degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, 2010).

3.2.2. Biological Resources

The most recent EISs prepared by BOEMRE for oil and gas lease sales in the Gulf of Mexico detail potential localized impacts to specific species from reasonably foreseeable oil spills. However, a catastrophic event, such as a high-volume, extended-duration spill resulting from a blowout, has the potential to cause population-level impacts. Multiple Federal and State-listed, threatened and endangered species could be impacted from an extended offshore spill (USDOI, FWS, 2010a and 2010b).

3.2.2.1. Marine and Migratory Birds

During Phase 2 of a catastrophic spill, the primary concern for marine and migratory birds would be their vulnerability to oiling or ingesting oil, which is related to their behavior. Wading birds (e.g., herons, egrets, etc.) and species that feed by plunge-diving into the water to catch small fish (e.g., pelicans, gannets, terns, gulls, and pelagic birds) and those that use water as a primary means of locomotion, foraging, or resting and preening (e.g., diving ducks, cormorants, pelicans, etc.) are highly vulnerable to becoming oiled and also to ingesting oil, as are black skimmers. These birds tend to feed and concentrate in convergence zones, places in the ocean where strong opposing currents meet. In addition to concentrating prey, these zones also aggregate oil (Unified Incident Command, 2010d). Oiling interferes with the birds' ability to fly (thus to obtain food) and compromises the insulative characteristics of down and contour feathers making it difficult to maintain body heat. Attempts by the birds to remove the oil by preening causes oiled birds to ingest oil and may result in mortality.

3.2.2.2. Fish, Fisheries, and Essential Fish Habitat

Early life stages of animals are usually more sensitive to oil than adults (Boesch and Rabalais, 1987; NRC, 2005). Weathered crude oil has been shown in laboratory experiments to cause malformation, genetic damage, and even mortality at low levels in fish embryos of Pacific herring (Carls et al., 1999). There is a high probability of mortality for the eggs and larvae of Gulf fishes that come in contact with spilled oil.

Adult fish may be less at risk than earlier life stages in part because they are less likely to concentrate at the surface and may avoid contact with floating oil. There were, however, sightings of whale sharks (which are defined as "threatened" by the International Union for Conservation of Nature) swimming among slicks from the *Deepwater Horizon* spill. They were not visibly oiled, but there was concern that they could be affected because they are surface feeders (Howell, 2010). Effects of oil on organisms can include direct lethal toxicity, sublethal disruption of physiological processes (internal lesions), effects of direct coating by oil (suffocation by coating gills), incorporation of hydrocarbons in organisms causing tainting or accumulation in the food chain, and changes in biological habitat (decreased dissolved oxygen) (Moore and Dwyer, 1974).

Because oil found in the Gulf of Mexico would generally float on the surface, fish species whose eggs and larvae are found at or near the water surface are most at risk from an offshore spill. Species whose spawning periods coincide with the timing of the highest oil concentrations would be at greatest risk. If there is a subsea catastrophic blowout, it is assumed dispersants would be used. Then there could be

effects on multiple life history stages and trophic levels. There is limited knowledge of the toxicity of dispersants mixed with oil to specific species or life stages of ichthyoplankton, and the likely extent of mortality due to the combination of factors is difficult to determine. The combined toxic effects of the oil and any dispersants that may be used may not be apparent unless a significant portion of a year-class is absent from next year's fishery (e.g., shrimps, crabs, snapper, and tuna).

Recent studies by USEPA using representative species provide some indication of the relative toxicity of Louisiana sweet crude oil, dispersants, and oil/dispersant mixes. Bioassays were conducted using two Gulf species—a mysid shrimp (*Amercamysis bahia*) and a small estuarine fish, the inland silverside (*Menidia beryllinina*)—to evaluate the acute toxic effects of oil, eight dispersants, and oil/dispersant mixtures. In addition, USEPA used standard *in vitro* techniques using the same dispersants to (1) evaluate acute toxicity on three cell lines over a range of concentrations and (2) evaluate effects of these dispersants on androgen and estrogen function using human cell lines (to see if they are likely to disrupt hormonal systems). All dispersants showed cytotoxicity in at least one cell type at concentrations between 10 and 110 parts per million (ppm). Results of the *in vitro* toxicity tests were similar to the whole animal tests, showing generally low dispersant toxicity. Lethal concentration (LC50) values (the concentration at which half of the test subjects die) were lower than the cell-based assays. For all eight dispersants, for both species, the dispersants alone were less toxic than the dispersant/oil mixture. Louisiana sweet crude oil alone was determined to be more toxic to both the silverside fish and the mysid shrimp than the dispersants alone. The results of the testing for disruption of androgen and estrogen function indicate that the dispersants do not show biologically significant endrocrine activity via androgen or estrogen pathways (USEPA, Office of Research and Development, 2010a and 2010b).

The North Atlantic bluefin tuna is an example of a fish/fishery in the Gulf of Mexico that could be at risk to lose a year-class. It has a relatively narrow peak spawning period in April and May and floating eggs. A catastrophic blowout during the spring season could cause a negative effect to this population. The Gulf of Mexico is one of only two documented spawning grounds for the Atlantic bluefin tuna; the other is in the Mediterranean Sea. Spawning is clustered in a specific type of habitat along the continental slope. Bluefin tuna are among the most valuable fish in global markets. The International Commission for the Conservation of Atlantic Tunas (ScienceDaily, 2010) currently manages the Atlantic bluefin tuna as two distinct populations, with western Atlantic spawners of the Gulf of Mexico forming a population genetically distinct from the eastern spawners of the Mediterranean Sea. The western Atlantic stock has suffered, and a significant and a long-term rebuilding plan has failed to revive the population or the fishery. The failure of the Gulf of Mexico spawning population to rebuild and the scope of illegal and under-reported catches are of such concern that the species was considered for Appendix 1 listing (most endangered status) by the Convention of International Trade in Endangered Species (CITES) in March 2010.

A catastrophic deepwater spill could release natural gases with methane as the primary component (NaturalGas.org, 2010) into the water column, but little is known about the effects of elevated methane levels on fish. Patin (1999) studied the elevated concentrations of methane resulting from a gas blowout from drilling platforms in the Sea of Asov on fish. The pathological changes reported were species specific and included damages to cell membranes, organs, and tissues; modifications of protein synthesis; and other anomalies typical for acute poisoning of fish. These impacts, however, were observed at levels of 4-6 milligrams/liter of methane near the accidental well. The full effect of elevated methane levels on Gulf of Mexico fishes is currently unknown.

3.2.2.3. Marine Mammals

An oil spill and related spill-response activities can impact marine mammals that come into contact with oil and remediation efforts. The marine mammals' exposure to hydrocarbons persisting in the sea may result in sublethal impacts (e.g., decreased health, reproductive fitness, longevity, and increased vulnerability to disease), some soft tissue irritation, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats or migration routes. More detail on the potential range of effects to marine mammals from contact with spilled oil can be found in Geraci and St. Aubin (1990). The best available information does not provide a complete understanding of the effects of the spilled oil and active response/cleanup

activities on marine mammals. For example, it is expected that the large amount of chemical dispersants being used on the oil may act as an irritant on the marine mammals' tissues and sensitive membranes.

The increased human presence after an oil spill (e.g., vessels) would likely add to changes in behavior and/or distribution, thereby potentially stressing marine mammals further and perhaps making them more vulnerable to various physiologic and toxic effects. In addition, the large number of response vessels could place marine mammals at a greater risk of vessel collisions, which could cause fatal injuries.

The Potential Biological Removal (PBR) level is defined by the Marine Mammal Protection Act (MMPA) as the maximum number of animals, not including natural mortalities that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. However, in the Gulf of Mexico, many marine mammal species have either entirely unknown PBRs or population size estimates that are more than 8 years old and therefore considered unknown. The biological significance of any injury or mortality would depend, in part, on the size and reproductive rates of the affected stocks, as well as the number, age, and size of the marine mammals affected.

According to the Consolidated Fish and Wildlife Collection Reports from the *Deepwater Horizon* incident, 103 marine mammals have been collected (9 alive and 94 deceased as of September 22, 2010). Thus, a high-volume oil spill lasting 120 days, could directly impact as many individuals or more. The majority would likely be coastal or estuarine bottlenose dolphins, as was the case with the *Deepwater Horizon* incident. This number represents only those marine mammals collected (either dead or alive) and does not address all potential impacts to the population. Based on these data, it is reasonable to assume that a catastrophic oil spill lasting up to 120 days could have population-level effects on many species of marine mammals (e.g., sperm whales, Bryde's whales, etc.).

3.2.2.4. Sea Turtles

Sea turtles are more likely to be affected by a catastrophic spill in shallow water than in deep water because not all sea turtles occupy a deepwater habitat. For example, Kemp's ridley sea turtles are unlikely to be in water depths of 160 feet or greater. Hawksbill sea turtles are commonly associated with coral reefs, ledges, caves, rocky outcrops, and high energy shoals. Green sea turtles are commonly found in coastal benthic feeding grounds, although they may also be found in the convergence zones of the open ocean. Convergence zones are areas that also may collect oil. Leatherback sea turtles are commonly pelagic and are the sea turtle species most likely to be affected by a deepwater oil spill. As the spilled oil moves toward land, additional species of sea turtles are more likely to be affected.

Based on the Consolidated Fish and Wildlife Collection Reports from the *Deepwater Horizon* incident, a few to over two dozen sea turtles could be impacted daily through oiling and/or collection. A high-volume oil spill lasting 120 days could impact greater than 1,000 sea turtles, and the majority could be Kemp's ridley turtles, which are listed as endangered under the ESA (USDOC, NOAA, NMFS, 2010a; Unified Incident Command, 2010e). In addition, the large number of response vessels could place sea turtles at a greater risk of vessel collisions, which could cause fatal injuries.

3.2.2.5. Offshore Habitats

Sargassum mats, which are mats made from a free-floating seaweed, provide habitat for juvenile sea turtles and developing invertebrates, spawning sites for hundreds of fish species, and feeding sources for manatees. "In offshore waters, both free-floating patches of sargassum seaweed and spilled oil tend to accumulate in convergence zones, places in the ocean where strong opposing currents meet. Sea turtles, especially juveniles, use these areas for food and cover. Burn operations sometime occur there because of the aggregated oil" (Unified Incident Command, 2010d). Benthic resources are discussed below.

3.2.2.6. Continental Shelf Benthic Resources

A spill from a shallow-water blowout could impact benthic communities on the continental shelf due to the blowout's proximity to these habitats. A spill from a deepwater blowout could also impact shelf communities if oil that was chemically dispersed at the seafloor is transported to these areas.

Soft-Bottom Benthic Communities

Soft-bottom infaunal communities that come into direct contact with oil or dispersed oil may experience sublethal and/or lethal effects. Localized areas of lethal effects would be recolonized by populations from neighboring soft-bottom substrate once the oil in the sediment has been sufficiently reduced to a level able to support marine life (Sanders et al., 1980). This initial recolonization process may be fairly rapid, but full recovery may take up to 10 years depending on the species present, substrate in the area, toxicity of oil spilled, concentration and dispersion of oil spilled, and other localized environmental factors that may affect recruitment (Kingston et al., 1995; Gesteira and Dauvin, 2000; Sanders et al., 1980; Conan, 1982). Opportunistic species would take advantage of the barren sediment, repopulating impacted areas first. These species may occur within the first recruitment cycle of the surrounding populations or from species immigration from surrounding stocks and may maintain a stronghold in the area until community succession begins (Rhodes and Germano, 1982; Sanders et al., 1980).

Long-term or low-level exposure may occur to benthic infauna as a result of oil adhering to sediment. Mesocosm experiments using long-term, low-level concentrations of No. 2 fuel oil indicate acute toxicity to meiofauna due to direct oil contact and sublethal effects from sedimented oil and byproducts of the decomposition of the sedimented oil (Frithsen et al., 1985). Long-term exposure to low levels of fuel oil was shown to affect recruitment success; meiofaunal population recovery took between 2 and 7 months (Frithsen et al., 1985). Oil entrained within sediments at the seafloor could create a layer toxic to infaunal species. This layer will persist through burial unless it is sufficiently degraded over time. Continued deposition of pelagic material could bury the layer, but it will remain intact over some timeframe as a potentially toxic or lethal horizon.

Continued localized disturbance of soft-bottom communities may occur during oil-spill response efforts. Anchors used to set booms to contain oil or vessel anchors in decontamination zones may affect infaunal communities in the response activity zone. Infaunal communities may be altered in the anchor scar and deposition of suspended sediment may result from the setting and resetting of anchors. The disturbed benthic community should begin to repopulate from the surrounding communities during their next recruitment event and through immigration of organisms from surrounding stocks. Any decontamination activities, such as cleaning vessel hulls of oil, may also contaminate the sediments of the decontamination zone, as some oil may settle to the seabed, impacting the underlying benthic community.

If a blowout occurs at the seafloor, drilling muds (primarily barite) may be pumped into a well in order to “kill” it. If a kill is not successful, the mud (possibly tens of thousands of barrels) may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath heavy layers of the extruded drilling mud would be buried. Base fluids of drilling muds are designed to be low in toxicity and biodegradable in offshore marine sediments (Neff et al., 2000). However, as bacteria and fungi break down the drilling fluids, the sediments may be come anoxic (Neff et al., 2000). Benthic macrofaunal recovery would occur when drilling mud concentrations are reduced to levels that enable the sediment to become re-oxygenated (Neff et al., 2000). Complete community recovery from drilling mud exposure may take 3-5 years, although microbial degradation of drilling fluids, followed by an influx of tolerant opportunistic species is anticipated to begin almost immediately (Neff et al., 2000). In addition, the extruded mud may bury hydrocarbons from the well, making them a hazard to the infaunal species and difficult to remove.

Hard-Bottom Benthic Communities

Sensitive reef communities flourish wherever hard bottoms occur in the Gulf of Mexico. Several categories are protected by BOEMRE. The eastern Gulf of Mexico contains scattered, low-relief live-bottoms including areas of flat limestone shelf rock. Potentially sensitive biological features are 8 feet or more above the seafloor. The Pinnacle Trend area includes low- and high-relief features and is 60-120 m (200-400 ft) below the sea surface, and topographic features are high relief and generally 15 m (49 ft) or more below the sea surface. Their depth below the sea surface protects all of these habitats from a surface oil spill.

Although hard-bottom benthic communities are initially buffered from surface oil slicks by their depth below the sea surface, surface oil may be brought to depth through physical processes. Rough seas may mix the oil into subsurface water layers, where it may impact sessile biota. The total time during

which seas are rough would help affect the amount of oil from a surface slick that would be mixed into the water column. Measurable amounts of oil have been documented down to a 10-m (33-ft) depth, although modeling exercises have indicated such oil may reach a depth of 20 m (66 ft). At this depth, however, the oil is found at concentrations several orders of magnitude lower than the amount shown to have an effect on corals (Lange, 1985; McAuliffe et al., 1975 and 1981; Knap et al., 1985).

The presence of a subsurface oil plume may affect hard-bottom communities. A portion of the oil released is expected to rise rapidly to the sea surface. However, upward movement of the oil may be reduced if methane in the oil is dissolved under high pressures, and oil droplets may become entrained deep in the water column (Adcroft et al., 2010). Subsurface plumes generated by high-pressure dissolution of oil may come in contact with hard-bottom features. A sustained spill would continuously create surface slicks and possibly subsurface spill plumes. Some of the oil in the water column will become diluted or evaporated over time, reducing any localized transport to the seafloor (Vandermeulen, 1982). In addition, microbial degradation of the oil occurs in the water column so that the oil would be less toxic when it contacts the seafloor (Hazen et al., 2010). However, a sustained spill may result it elevated exposure concentrations to hard-bottom features if the plume reaches them. The longer the spill takes to stop, the longer the exposure time and concentration may be.

Low-level exposures of corals to oil from a subsea plume may result in chronic or temporary impacts. For example, feeding activity or reproductive ability may be reduced when coral is exposed to low levels of oil; however, impacts may be temporary or unable to be measured over time. Experiments indicated that normal feeding activity of *Porites porites* and *Madracis asperula* were reduced when exposed to 50 ppm oil (Lewis, 1971). Reefs of *Siderastrea sidereal* that were oiled in a spill produced smaller gonads than unoiled reefs, resulting in reproductive stress (Guzmán and Holst, 1993).

Elevated concentrations of oil may be necessary to measure reduced photosynthesis or growth in corals. Photosynthesis of the zooxanthellae in *Diplora strigosa* exposed to approximately 18-20 ppm crude oil for 8 hours was not measurably affected, although other experiments indicate that photosynthesis may be impaired at higher concentrations (Cook and Knap, 1983). Measurable growth of *Diploria strigosa* exposed to oil concentrations up to 50 ppm for 6-24 hours did not show any reduced growth after 1 year (Dodge et al., 1984).

Corals exposed to subsea oil plumes may incorporate petroleum hydrocarbons into their tissue. Records indicate that *Siderastrea siderea*, *Diploria strigosa*, and *Montastrea annularis* accumulate oil from the water column and incorporate petroleum hydrocarbons into their tissues (Burns and Knap, 1989; Knap et al., 1982; Kennedy et al., 1992). Most of the petroleum hydrocarbons are incorporated into the coral tissues, not their mucus (Knap et al., 1982). However, hydrocarbon uptake may also modify lipid ratios of coral (Burns and Knap, 1989). If lipid ratios are modified, mucus synthesis may be impacted, adversely affecting the coral's ability to protect itself from oil through mucus production (Burns and Knap, 1989).

If dispersants are used on the seafloor or at the surface, oil may mix into the water column well below the surface, can travel with currents through the water, and may contact settle on hard bottoms. If near the source, the dispersed oil could be concentrated enough to harm the community. If the oil remains suspended for a longer period of time, it would be more dispersed and present at lower concentrations. Reports on dispersant usage on surface plumes indicates that a majority of the dispersed oil remains in the top 10 m of the water column, with 60 percent of the oil in the top 2 m (McAuliffe et al., 1981). Dispersant usage also reduces the oil's ability to stick to particles in the water column, minimizing sedimented oil traveling to the seafloor (McAuliffe et al., 1981).

Dispersed oil reaching the benthic hard-bottom communities in the Gulf of Mexico would be expected to be at very low concentrations (less than 1 part per million) (McAuliffe et al., 1981). Such concentrations would not be life threatening to larval or adult stages at depth based on experiments conducted with coral. Any dispersed oil in the water column that comes in contact with corals may evoke short-term negative responses by the organisms (Wyers et al., 1986; Cook and Knap, 1983; Dodge et al., 1984).

Reductions in feeding and photosynthesis are some impacts that may occur to coral exposed to dispersed oil. Short-term, sublethal responses of *Diploria strigosa* were reported after exposure to dispersed oil at a concentration of 20 ppm for 24 hours. Although concentrations in this experiment were higher than what is anticipated for dispersed oil at depth, effects exhibited included mesenterial filament extrusion, extreme tissue contraction, tentacle retraction, and localized tissue rupture (Wyers et al., 1986).

Normal behavior resumed within 2 hours to 4 days after exposure (Wyers et al., 1986). *Diploria strigosa* exposed to dispersed oil (20:1, oil:dispersant) showed an 85 percent reduction in zooxanthellae photosynthesis after 8 hours of exposure to the mixture (Cook and Knap, 1983). However, the response was short-term, as recovery occurred between 5 and 24 hours after exposure and return to clean seawater. Investigations 1 year after *Diploria strigosa* was exposed to concentrations of dispersed oil between 1 and 50 ppm for periods between 6 and 24 hours did not reveal any impacts to growth (Dodge et al., 1984).

Dispersed oil does appear to be more toxic to coral species than oil or dispersant alone. The greater toxicity may be a result of and increased number of oil droplets caused by the use of dispersant, resulting in greater contact area between oil, dispersant, and water (Elgershuizen and Kruijf, 1976). The dispersant causes a higher water-soluble amount of oil to contact the cell membranes of the coral (Elgershuizen and Kruijf, 1976). The mucus produced by coral, however, can protect the organism from oil. Both hard and soft corals have the ability to produce mucus, and mucus production has been shown to increase when corals are exposed to crude oil (Mitchell and Chet, 1975; Ducklow and Mitchell, 1979). Dispersed oil however, which has very small oil droplets, does not appear to adhere to coral mucus, and larger untreated oil droplets may become trapped by the mucus barrier (Knap, 1987; Wyers et al., 1986). However, entrapment of the larger oil droplets may increase the coral's long-term exposure to oil if the mucus is not shed in a timely manner (Knap, 1987; Bak and Elgershuizen, 1976).

Although dispersed oil may be more toxic than untreated oil to corals during exposure experiments, untreated oil may remain in the ecosystem for long periods of time, while dispersed oil does not (Baca et al., 2005; Ward et al., 2003). Twenty years after an experimental oil spill in Panama, oil and impacts from untreated oil were still observed at oil treatment sites, but no oil or impacts were observed at dispersed oil or reference sites (Baca et al., 2005). Long-term recovery of the coral at the dispersed oil site had already occurred as reported in a 10-year monitoring update, and the site was not significantly different from the reference site (Ward et al., 2003).

The BOEMRE policy prevents wells from being placed immediately adjacent to sensitive communities. In the event of a seafloor blowout however, some oil could be carried to hard bottoms as a result of oil droplets sedimenting to suspended particles in the water column. Oiled sediment that settles to the seafloor may affect organisms attached to hard-bottom substrates. Impacts may include reduced recruitment success, reduced growth, and reduced coral cover as a result of impaired recruitment. Experiments have shown that the presence of oil on available substrate for larval coral settlement has inhibited larval metamorphosis and larval settlement in the area. There were also an increased number of deformed polyps after metamorphosis due to oil exposure (Kushmaro et al., 1997).

The majority of organisms exposed to sedimented oil however, are anticipated to experience low-level concentrations because as the oiled sediments settle to the seafloor they are widely dispersed. Coral may also be able to protect itself from low concentrations of sedimented oil that settles from the water column. Coral mucus may not only act as a barrier to protect coral from the oil in the water column but it has also been shown to aid in the removal of oiled sediment on coral surfaces (Bak and Elgershuizen, 1976). Coral may use a combination of increased mucus production and ciliary action to rid themselves of oiled sediment (Bak and Elgershuizen, 1976).

Oil-spill response activity may also impact sessile benthic features. Booms anchored to the seafloor are sometimes used to control the movement of oil at the water surface. Boom anchors can physically impact corals and other sessile benthic organisms, especially when booms are moved around by waves (Tokotch, 2010). Vessel anchorage and decontamination stations set up during response efforts may also break or kill hard-bottom features as a result of setting anchors. Injury to coral reefs as a result of anchor impact may result in long-lasting damage or failed recovery (Rogers and Garrison, 2001). Effort should be made to keep vessel anchorage areas as far from sensitive benthic features as possible to minimize impact.

Drilling muds comprised primarily of barite may be pumped into a well to stop a blowout. If a "kill" is not successful, the mud (possibly tens of thousands of barrels) may be forced out of the well and deposited on the seafloor near the well site. Any organisms beneath the extruded drilling mud would be buried. Based on NTL 2009-G39, a well should be far enough away from a hard-bottom community to prevent extruded drilling muds from smothering benthic communities. However, if drilling muds were to travel far enough or high enough in the water column to contact a hard-bottom community, the fluid would smother the existing community. Experiments indicate that corals perish faster when buried beneath drilling mud than when buried beneath carbonate sediments (Thompson, 1980). As discussed

earlier, as the drilling fluids biodegrade, an anoxic zone surrounding the activity may occur. Recolonization would occur from the surrounding community once the area has enough oxygen to support new growth, which may take 3-5 years (Neff et al., 2000).

3.2.2.7. Deepwater Benthic Communities

It is not likely that deepwater benthic communities would be impacted by a spill from a shallow water blowout. However, a spill resulting from a catastrophic blowout in deep water has the potential to impact offshore benthic communities due to the blowout's proximity to these habitats and the use of subsea dispersants.

Much of the oil is expected to be treated with dispersants at the sea surface and possibly subsea at the source in the event of a deep water blowout. The dispersed oil is mixed with the water, and its movement is then dictated by local currents and the physical, chemical, and biological degradation pathways. The oil would become more dispersed, less concentrated, and more biodegraded the longer it remains suspended in the water column. Depending on how long it remained suspended in the water column, it may be thoroughly degraded by biological action before contact with the seafloor and its sensitive resources occurs (Hazen et al., 2010; Valentine et al., 2010). Biodegradation rates in colder, deepwater environments are not well understood at this time. Oil may reach the seafloor in the following ways: as microbes begin to consume the oil particles; when the dispersed oil particles may flocculate (flocculation is suspended particles collecting into larger suspended flakes),), thus increasing the density of the particles such that they are no longer in isostatic balance with the surrounding water and thus, sink to the seafloor; when larger plankton consume the bacteria-rich oil particles and their fecal pellets are excreted and distributed over the seafloor; when water currents carry a plume to contact the seafloor directly; or most likely, where the dispersed oil to adhere to other particles and sink to the seafloor. This last scenario would result in a wide distribution of small amounts of oil. This oil could be in the process of biodegradation from bacterial action that would continue on the seafloor, resulting in scattered microhabitats with an enriched carbon environment. Biodegradation processes, both on the bottom and in the water column, would be expected to cause at least some reduction of normal ambient dissolved oxygen levels; however, this has yet to be observed at a level that would be detrimental to animal respiration (Hazen et al., 2010).

Deepwater Soft-Bottom Benthic Communities

Soft bottoms are the overwhelming majority of the deep-sea environment. Large amounts of oil would only affect these deep environments if dispersants are used. As described above, the toxic effects of dispersed oil would continue to reduce as the concentration of oil is reduced via dispersion, localized mixing, and biodegradation. As with shelf habitats, the only soft bottom that is expected to suffer significant effects would be soft bottoms in the immediate vicinity of a seafloor blowout in which some oil is mixed into the sediment. In situations where soft-bottom infaunal communities are negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all size ranges of organisms—a matter of days for bacteria and probably less than 1 year for most macrofauna and megafauna species. This could take longer for areas affected by direct oil contact in higher concentrations.

Deepwater Coral Benthic Communities

There have been no experiments showing the response of deepwater corals to oil exposure. Experiments with shallow tropical corals indicate that corals have a high tolerance to oil exposure. The mucus layers on coral resist penetration of oil and slough off the contaminant. Longer exposure times and areas of tissue where oil adheres to the coral are more likely to result in tissue damage and death of polyps. Corals with branching growth forms appear to be more susceptible to damage from oil exposure (Shigenaka, 2001). The most common deepwater coral, *Lophelia pertusa*, is a branching species. Tests with shallow tropical gorgonians indicate relatively low toxic effects to the coral (Cohen et al., 1977), suggesting deepwater gorgonians may have a similar response. Response of deepwater coral to oil exposure from a catastrophic spill would vary, depending on the level of exposure. Exposure to widely dispersed oil adhering to organic detritus and partially degraded by bacteria may be expected to result in

little effect. Direct contact with plumes of relatively fresh dispersed oil droplets in the vicinity of the incident could cause death of affected coral polyps through exposure and potential feeding on oil droplets by polyps. Median levels of exposure to dispersed oil in a partly degraded condition may result in effects similar to those of shallow tropical corals, with often no discernable effects other than temporary contraction and some sloughing. The health of corals may be degraded by the necessary expenditure of energy as the corals respond to oiling (Shigenaka, 2001). Communities exposed to more concentrated oil may experience detrimental effects, including death of affected organisms, tissue damage, lack of growth, interruption of reproductive cycles, and loss of gametes. Many invertebrates associated with deepwater coral communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure. The recolonization of severely damaged or destroyed communities could take years or decades. However, because of the scarcity nature of deepwater hard bottoms and the comparatively low surface area, it is unlikely that a sensitive habitat would be located near a seafloor blowout, or if near, that concentrated oil would contact the site.

Deepwater Chemosynthetic Benthic Communities

Chemosynthetic communities, which are adapted to gas seeps which sometimes release oil also. They may receive. . . , low quantities of well-dispersed oil undergoing biodegradation may and experience little negative effect. Exposure may be similar to normal conditions for these communities and may be within the normal variation of habitat conditions. However, oil contact could cause some fluctuation in organism health, resulting in slower growth or delayed spawning. Since these organisms grow slowly, sublethal effects could eliminate a year or more of normal growth. Communities exposed to more concentrated oil may experience detrimental effects, including death of affected organisms, tissue damage, lack of growth, interruption of reproductive cycles, and loss of gametes. Other invertebrates associated with chemosynthetic communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure. Recolonization of severely damaged or destroyed communities could take years or decades.

3.2.3. Socioeconomic Resources

3.2.3.1. Offshore Archaeological Resources

Due the response methods (i.e., subsea dispersants) and magnitude of the response (i.e., thousands of vessels), a catastrophic blowout and spill have a greater potential to impact offshore archaeological resources than other accidental events.

Deep Water

In contrast to smaller spills or spills in shallow water, the use of large quantities of subsea dispersants could be used for a catastrophic subsea blowout in deep water. This could result in currently unknown effects from dispersed oil droplets settling to the seafloor. Though information on the actual impacts to submerged cultural resources is inconclusive at this time, oil settling to the seafloor could come in contact with archaeological resources. At present, there is no evidence of this having occurred. A recent experimental study has suggested that, while the degradation of wood in terrestrial environments is initially retarded by contamination with crude oil, at later stages, the biodeterioration of wood was accelerated (Ejechi, 2003). While there are different environmental constraints that affect the degradation of wood in terrestrial and waterlogged environments, soft-rot fungal activity, one of the primary wood degrading organisms in submerged environments, was shown to be increased in the presence of crude oil. There is a possibility that oil from a catastrophic blowout could come in contact with wooden shipwrecks and artifacts on the seafloor and accelerate their deterioration.

Ancillary damages from vessels associated with oil-spill response activities (e.g., anchoring) in deep water are unlikely due to the use of dynamically positioned vessels responding to a deepwater blowout. If response and support vessels were to anchor near a deepwater blowout site, the potential to damage undiscovered vessels in the area would be high due to the required number and the size of anchors and the length of mooring chains needed to safely secure vessels. Additionally, multiple offshore vessel decontamination stations would likely be established in shallow water outside of ports or entrances to

inland waterways, as seen for the *Deepwater Horizon* incident. The anchoring of vessels could result in damage to both known and undiscovered archaeological sites; the potential to impact archaeological resources increases as the density of anchoring activities in these areas increases.

Shallow Water

The potential for damaging archaeological resources increases as the oil spill and related response activities progress landward. In shallower waters, most of the damage would be associated with oil cleanup and response activities. Thousands of vessels would respond to a shallow-water blowout and would likely anchor, potentially damaging both known and undiscovered archaeological sites. Additional anchoring would be associated with offshore vessel decontamination stations, as described above. As the spill moves into the intertidal zone, the chance of direct contact between the oil and archaeological resources increases. As discussed above, this could result in increased degradation of wooden shipwrecks and artifacts.

Additionally, in shallower waters, shipwrecks often act as a substrate to corals and other organisms, becoming an essential component of the marine ecosystem. These organisms often form a protective layer over the shipwreck, virtually encasing the artifacts and hull remains. If these fragile ecosystems were destroyed as a result of the oil spill and the protective layer removed, the shipwreck would then be exposed to increased degradation until it reaches a new level of stasis with its surroundings.

Regardless of water depth, because oil is a hydrocarbon, heavy oiling could contaminate organic materials associated with archaeological sites, resulting in erroneous dates from standard radiometric dating techniques (e.g., ^{14}C-dating). Interference with the accuracy of ^{14}C-dating would result in the loss of valuable data necessary to understand and interpret the sites.

3.2.3.2. Commercial Fishing

In 2008, the Gulf of Mexico provided over 33 percent of the commercial fishery landings in the continental U.S. (excluding Alaska), with nearly 1.3 billion pounds valued at nearly $660 million. (USDOC, NMFS, 2010).

Even though sensory and chemical testing may show no detectable oil or dispersant odors or flavors and the results could be well below the levels of concern, NOAA Fisheries would be expected to close large portions of the Gulf of Mexico during a high-volume spill as a precautionary measure to ensure public safety and to assure consumer confidence in Gulf seafood (USDOC, NOAA, NOAA Fisheries Service, 2010a). Up to 30-40 percent of Gulf of Mexico Exclusive Economic Zone (EEZ) could be closed to commercial fishing as the spill continues and expands (USDOC, NOAA, NOAA Fisheries Service, 2010b). This area could represent 50-75 percent of the Gulf seafood production (Flynn, 2010). The closure area may peak about 50 days into the spill and persist another 2-3 months until the well is killed or capped and the remaining oil is recovered or dissipates. During this period, portions or all of individual State waters would also be closed to commercial fishing.

The economic impacts of closures on commercial fishing are difficult to predict because they are dependent on the season and would vary by fishery. If fishers cannot make up losses throughout the remainder of the season, a substantial part of their annual income would be lost. In some cases, commercial fishers will move to areas still open to fishing, but at a greater cost due to longer transit times. Marketing issues are also possible; even if the catch is uncontaminated, the public may lack confidence in the product.

3.2.3.3. Recreational Fishing

Up to 30-40 percent of the Gulf of Mexico EEZ could be closed to recreational fishing as the spill continues and expands (USDOC, NOAA Fisheries, 2010b). The closure area could peak about 50 days into the spill and continue for another 2-3 months until the well is killed or capped and the remaining oil is recovered or dissipates. During this period, portions or all of individual State waters would also be closed to recreational fishing.

In 2008, over 24 million recreational fishing trips were taken, which generated about $12 billion in sales, over $6 billion in value-added impacts, and over 100,000 jobs (USDOC, NOAA, NMFS, 2010b). About 33 percent of the total Gulf catch came on trips that fished primarily in Federal and State waters

(Pritchard, 2009). Recreational fishing is focused in the summer months. During this time, scheduled tournaments would be hard to reschedule. If the spill affected that time of year, normal direct income and indirect income to the communities that host these tournaments would be lost for that year. If a catastrophic spill occurs in the summer, a substantial number of recreational fishing trips would not occur and the economic benefits they generate would be lost for that year.

3.2.3.4. Tourism and Recreational Resources

While the spill is still offshore, there could be some ocean-dependent recreation that is affected (e.g., fishing, diving), as discussed above. In addition, there may be some effects due to either perceived damage to onshore recreational resources that has not yet materialized or to general hesitation on the part of travelers to visit the overall region due to the spill. For example, studies during the *Deepwater Horizon* oil spill show that perceptions can influence recreational activity, even if an oil spill has not yet damaged physical resources in an area (The Knowland Group, 2010; Market Dynamics Research Group, 2010). However, the majority of the impacts of a catastrophic spill would occur once the spill has contacted shore, as discussed in Section 4.2.3.4.

3.2.3.5. Employment and Demographics

In contrast to a less severe accidental event, suspension of some oil and gas activities would be likely following a catastrophic event. Depending on the duration and magnitude, this could impact hundreds of oil-service companies that supply the steel tubing, engineering services, drilling crews, and marine supply boats critical to offshore exploration. An interagency economic report estimated that the 6-month suspension, as a result of the *Deepwater Horizon* incident, may have directly and indirectly resulted in up to 8,000-12,000 fewer jobs along the Gulf Coast (Inter-agency, 2010b). Most of these jobs were not permanently lost as a result of the suspension and returned following the resumption of deepwater drilling in the Gulf of Mexico. These estimates are lower than earlier estimates of 15,000-60,000 rig and associated service jobs being at risk (Hargreaves, 2010; LMOGA, 2010; Zeller, 2010; Jindal, 2010).

Whatever the number, much of the employment loss would be concentrated in coastal oil-service parishes in Louisiana (St. Mary, Terrebonne, Lafourche, Iberia, and Plaquemines) and counties/parishes where drilling-related employment is most concentrated (Harris County, Texas, in which Houston is located, and Lafayette Parish, Louisiana) (Nolan and Good, 2010; U.S. Department of Labor, BLS, 2010). There would be additional economic impacts to commercial and recreational fishing, as discussed in Sections 3.2.3.2 and 3.2.3.3. This impact is also expected to be more heavily concentrated in smaller businesses than in the larger companies (Inter-agency, 2010b).

Demographic impacts are unlikely from temporary job losses.

3.2.3.6. Land Use and Coastal Infrastructure

Impacts to tourism and recreational resources are addressed in Section 3.2.3.4. Possible fisheries closures are addressed in Sections 3.2.3.2 and 3.2.3.3. While still offshore, a catastrophic oil spill would not impact other land use or coastal infrastructure.

3.2.3.7. Environmental Justice

The environmental justice policy, based on Executive Order 12898 of February 11, 1994, directs agencies to incorporate into NEPA documents an analysis of potentially disproportionate and detrimental environmental and health effects of their proposed actions on minorities and low-income populations and communities. While the spill is still offshore, the primary environmental justice concern would be large commercial fishing closures disproportionately impacting minority fishers. In the event of a catastrophic spill, Federal and State agencies would be expected to close substantial portions of the Gulf to commercial and recreational fishing (USDOC, NOAA, 2010g). While oystering occurs “onshore,” oyster beds are also likely to be closed to harvests during Phase 2 of a catastrophic spill due to concerns about oil contamination and increased freshwater diversions to mitigate oil intrusion into the marshes (see Sections 3.2.3.2 and 3.2.3.3). These closures would directly impact commercial fishermen and oysterers, and indirectly impact such downstream activities as shrimp processing facilities and oyster shucking

houses. The mostly African-American communities of Phoenix, Davant and Point a la Hache in Plaquemines Parish are home to families with some of the few black-owned oyster leases, which because of freshwater diversion projects for coastal restoration have already been threatened (Mock, 2010).

The Gulf Coast hosts multiple minority and low-income groups whose use of natural resources of the offshore and coastal environments make them vulnerable to fishing closures. While not intended as an inventory of the area's diversity, we have identified several Gulf Coast populations of particular concern. An estimated 20,000 Vietnamese fishermen and shrimpers live along the Gulf Coast; by 1990, over 1 in 20 Louisiana fishers and shrimpers had roots in Southeast Asia even though they comprised less than half a percent of the state's workforce (Bankston and Zhou, 1996). Vietnamese account for about one-third of all the fishermen in the central Gulf of Mexico (Ravitz, 2010). Islaños, African Americans, and Native American groups are also engaged in commercial fishing and oystering. Historically, Vietnamese and African Americans have worked in the fish processing and oyster shucking industries. Shucking houses particularly, have provided an avenue into the mainstream economy for minority groups.

Therefore, fishing closures during Phase 2 of a catastrophic spill impacting the central Gulf of Mexico would disproportionately affect such minority groups as the Vietnamese, Native Americans, African Americans, and Islaños (Hemmerling and Colten, 2003).

4. ONSHORE CONTACT (PHASE 3)

4.1. IMPACT-PRODUCING FACTORS AND SCENARIO

4.1.1. Duration

The duration of the shoreline oiling is measured from initial shoreline contact until the well is capped or killed and the remaining oil dissipates offshore. The time needed to cap or kill a well may vary, depending on the well's water depth. Depending on the spill's location in relation to winds and currents and the well's distance to shore, oil could reach the coast within 1 week to 1 month, based on evidence from previous spills in the Gulf of Mexico OCS. While it is assumed that the majority of spilled oil would dissipate offshore within 30 days of stopping the flow, some oil may remain in coastal areas until cleaned, as seen in Louisiana following the *Deepwater Horizon* blowout (The State of Louisiana, 2010a-d).

4.1.1.1. Shallow Water

Due to the distance from shore, oil spilled as a result of a blowout in shallow water could reach shore within 1-3 weeks and could continue until the well is killed or capped (1-3 months) and the oil dissipates offshore (1 month). Therefore, it is estimated that shoreline oiling would likely occur for 1-4 months following a catastrophic blowout.

4.1.1.2. Deep Water

As discussed in Section 3.1.1, intervention is more difficult and would take longer in deeper water. In general, most of the deep water in the Gulf of Mexico is located far from shore and therefore, it is assumed that oil would reach shore within 2-4 weeks. While most deep water is located far from shore, some areas of deep water are located relatively near shore so that oil could reach shore earlier.

The length of shoreline oiled would continue to increase until the well is killed or capped (3-4 months) and oil dissipates offshore (1 month). Therefore, shoreline oiling could occur for 3 to more than 4 months following a catastrophic blowout.

4.1.2. Volume of Oil

In the event of a catastrophic spill, not all of the oil spilled would contact shore. The amount of oil recovered and chemically or naturally dispersed would vary. For example, the following are recovery and cleanup rates from previous high-volume, extended spills:

- 10-40 percent of oil recovered or cleaned up (including burned, chemically dispersed, and skimmed);

- 25-40 percent of oil naturally dispersed, evaporated, or dissolved; and
- 20-65 percent of the oil remains available for biodegradation offshore or in shore contact

In the case of the *Deepwater Horizon* incident, "it is estimated that burning, skimming and direct recovery from the wellhead removed one quarter (25%) of the oil released from the wellhead. One quarter (25%) of the total oil naturally evaporated or dissolved, and just less than one quarter (24%) was dispersed (either naturally or as a result of operations) as microscopic droplets into Gulf waters. The residual amount—just over one quarter (26%)—is either on or just below the surface as light sheen and weathered tar balls, has washed ashore or been collected from the shore, or is buried in sand and sediments" (Inter-agency, 2010a).

For planning purposes, USCG estimates that 5-30 percent of oil will reach shore in the event of an offshore spill (33 C.F.R. Part 154, Appendix C, Table 2.). Using the USCG assumptions, a catastrophic spill could still result in a large amount of oil reaching shore.

4.1.3. Length of Shoreline Contacted

While larger spill volumes increase the chance of oil reaching the coast, other factors that influence the length and location of shoreline contacted include the duration of the spill and the well's location in relation to winds, currents, and the shoreline. As seen with the *Deepwater Horizon* spill, as the spill continued, the length of oiled shoreline at any one time increased exponentially as follows:

Duration of Spill	Length of Shoreline Oiled1
30 days	0-50 miles
60 days	50-100 miles
90 days	100-1,000 miles
120 days	>1,000 miles[2]

[1] Not cumulative.
[2] Length was extrapolated.

Dependent upon winds and currents throughout the spill event, already impacted areas could be re-oiled.

4.1.3.1. Shallow Water

While a catastrophic spill from a shallow-water blowout is expected to be lower in volume than a deepwater blowout, as explained in Section 3.1, the site would be closer to shore, allowing less time for oil to be weathered, dispersed, and recovered. This could result in a more concentrated and toxic oiling of the shoreline.

4.1.3.2. Deep Water

While a catastrophic spill from a deepwater blowout is expected to have a much greater volume than a shallow-water blowout (see Section 3.1), the site would be farther from shore, allowing more time for oil to be weathered, dispersed, and recovered. This could result in a broader, patchier oiling of the shoreline.

Translocation of the spilled oil via winds and currents is also a factor in the length of shoreline contacted. For example, oil could enter the Loop Current and then the Gulf Stream. However, the longer it takes oil to travel, the more it would degrade, disperse, lose toxicity, and break into streamers and tarballs (USDOC, NOAA, Office of Response and Restoration, 2010d).

4.1.4. Severe Weather

The Atlantic hurricane season runs from June 1st through November 30th, peaking in September. In an average Atlantic season, there are 11 named storms, 6 hurricanes, and 2 Category 3 or higher storms (USDOC, NOAA, National Weather Service, 2010a). In the event of a hurricane, vessels would evacuate

the area, delaying response efforts, including the drilling of relief wells. The storm surge may push oil to the coastline and inland as far as the surge reaches, or the storm surge may remove the majority of oil from shore, as seen in some of the previous spills reviewed.

Movement of oil during a hurricane would depend greatly on the track of the hurricane in relation to the slick. A hurricane's winds rotate counter-clockwise. In general, a hurricane passing to the west of the slick could drive oil to the coast, while a hurricane passing to the east of the slick could drive the oil away from the coast.

4.1.5. Onshore Cleanup Activities

As described in Section 3.1, a large-scale response effort would be expected for a catastrophic blowout. The number of vessels and responders would increase exponentially as the spill continued. In addition to the response described in the Section 3.1.6, the following response is also estimated to occur once the spill contacts the shore.

An exponential increase in the length of shoreline impacted would likely overwhelm response efforts.

4.1.5.1. Shallow Water

- There would be 5-10 staging areas established.
- Weathering permitting, about 200-300 skimmers could be deployed near shore to protect coastlines.

4.1.5.2. Deep Water

- There would be 10-20 staging areas established.
- Weather permitting, about 500-600 skimmers could be deployed near shore to protect coastlines. As seen in Louisiana following the *Deepwater Horizon*, a few hundred coastal skimmers could still be in operation a few months after the well is capped or killed (The State of Louisiana, 2010e).

4.2. Most Likely and Most Significant Impacts

The most recent EISs prepared by BOEMRE for oil and gas lease sales in the Gulf of Mexico identify in detail the potential impacts from reasonably foreseeable oil spills (USDOI MMS, 2007 and 2008). The most likely and significant onshore impacts caused by a catastrophic spill are described below.

4.2.1. Physical Resources

4.2.1.1. Air Quality

As the spill nears shore, there would be low-level concentrations of odor-causing pollutants associated with evaporative emissions from the oil spill. These may cause temporary eye, nose, or throat irritation, nausea, or headaches, but the doses are not thought to be high enough to cause long-term harm (USEPA, 2010b). However, responders could be exposed to levels higher than OSHA permissible exposure levels (PEL) (U.S. Department of Labor, OSHA, 2010b). During the *Deepwater Horizon* oil spill, USEPA took air samples at various onshore locations along the length of the Gulf coastline. All except three measurements of benzene were below 3 parts per billion (ppb). The highest level was 91 ppb. During the *Deepwater Horizon* incident, air samples collected by BP, OSHA, and USCG near shore showed levels of benzene, toluene, ethylbenzene, and xylene that were mostly under detection levels. Among the 15,000 samples taken by BP, there was only one sample where benzene exceeded the OSHA Occupational PELs. All other sample concentrations were below the more stringent **American Conference of Governmental Industrial Hygienists (**ACGIH®**)** threshold limit values (TLVs) (U.S. Department of Labor, OSHA, 2010a). All measured concentrations of toluene, ethylbenzene, and xylene were well within the OSHA PELs and ACGIH TLVs.

4.2.1.2. Coastal Water Quality

Water quality governs the suitability of waters for plant, animal, and human use. Water quality is important in the bays, estuaries, and nearshore coastal waters of the Gulf because these waters provide feeding, breeding, and/or nursery habitat for many commercially significant invertebrates and fishes, as well as sea turtles, birds, and marine mammals. A catastrophic spill would significantly impact coastal water quality in the Gulf of Mexico. In the Gulf of Mexico, water quality prior to the *Deepwater Horizon* incident was rated as fair while sediment quality was rated as poor (USEPA, 2008). In addition, the coastal habit index, a rating of wetlands habitat loss, was also rated as poor. Both the sediment quality and the coastal habitat index affect water quality.

Though response efforts would decrease the amount of oil remaining in Gulf waters and reduce the amount of oil contacting the coastline, significant amounts of oil would remain. Coastal water quality would be impacted not only by the oil, gas, and their respective components, but also to some degree from cleanup and mitigation efforts. Increased vessel traffic, hydromodification, addition of dispersants and methanol in an effort to contain, mitigate, or clean up the oil may also tax the environment.

The use of dispersants as a response tool involves a tradeoff. The purpose of chemical dispersants is to facilitate the movement of oil into the water column in order to encourage weathering and biological breakdown of the oil (i.e., biodegradation) (NRC, 2005; Australian Maritime Safety Authority, 2010). Thus, the tradeoff is generally considered to be between the shoreline and surface of the water versus the water column and benthic resources (NRC, 2005). If the oil moves into the water column and is not on the surface of the water, it is less likely to reach sensitive shore areas (USEPA, 2010c). Since sea birds are often on the surface of the water or in shore areas, dispersants are also considered to be very effective in reducing the exposure of sea birds to oil (Australian Maritime Safety Authority, accessed 2010, http://www.amsa.gov.au/Marine_Environment_Protection/National_plan/General_Information/Dispersants_Information/FAQ_Oil_Spills_Dispersants.asp). In addition to dispersion being enhanced by artificial processes, oil my also be dispersed from natural processes. For instance, microbial metabolism of crude oil results in the dispersion of oil (Bartha and Atlas, 1983). Dispersion has both positive and negative effects. The positive effect is that the oil, once dispersed, is more available to be degraded. The negative effect is that the oil, once dispersed, is more available to microorganisms which temporarily increases the toxicity (Bartha and Atlas, 1983). Toxicity of dispersed oil in the environment will depend on many factors, including the effectiveness of the dispersion, temperature, salinity, the degree of weathering, type of dispersant and degree of light penetration in the water column (NRC, 2005). The toxicity of dispersed oil is primarily due to the toxic components of the oil itself (Australian Maritime Safety Authority, accessed 2010, http://www.amsa.gov.au/Marine_Environment_Protection/National_plan/General_Information/Dispersants_Information/FAQ_Oil_Spills_Dispersants.asp).

Oxygen and nutrient concentrations in coastal waters vary seasonally. The zone of hypoxia (depleted oxygen) on the Louisiana-Texas shelf occurs seasonally and is affected by the timing of freshwater discharges from the Mississippi and Atchafalaya Rivers, which carry nutrients to the surface waters. The hypoxic conditions continue until local wind-driven circulation mixes the water again. The 2010 hypoxic zone could not be linked to the *Deepwater Horizon* incident in either a positive or a negative manner (LUMCON, 2010). Nutrients from the Mississippi River fueled enhanced phytoplankton and attributed to the formation of the hypoxic zone.

4.2.2. Biological Resources

Recent EISs prepared by BOEMRE for oil and gas lease sales in the Gulf of Mexico detail the potential localized impacts to individuals from reasonably foreseeable oil spills. However, a catastrophic event, such as a high-volume, extended-duration spill resulting from a blowout has the potential to cause population level impacts, as described below.

Dozens of Federal and State-listed threatened and endangered species could continue to be impacted during Phase 3 of a catastrophic oil spill as oil and response activities persist, including marine mammals, sea turtles, fish, and birds. Additional species could be impacted in extreme conditions (i.e., oil is pushed onto beaches or into rivers or marshes due to a hurricane) (USDOI, FWS, 2010a and 2010b).

4.2.2.1. Coastal and Marine Birds

Gulf coastal habitats are essential to the annual cycles of many species of breeding, wintering and migrating waterfowl, wading birds, shorebirds, and songbirds. For example, the northern Gulf Coast supports a disproportionately high number of beach-nesting bird species (USDOI, FWS, 2010c). Once oil contacts shore, a few dozen to over a hundred birds could be impacted daily by oiling and/or collection. By extrapolating the number of birds impacted as a result of the *Deepwater Horizon* incident, a spill lasting 120 days could result in direct mortality of over 7,000 birds (USDOI, FWS, 2010d). This number does not reflect total realized mortality but rather only the actual number of birds recovered to date. This number represents a small fraction of total bird mortality due to carcasses sinking, being scavenged, drifting outside the search zone, or simply going undetected due to wind, current, weather, and habitat factors (Ford et al., 1987, Piatt et al., 1990, Fowler and Flint, 1997; Flint et al., 1999; Wiese and Robertson, 2004; Byrd et al., 2009). In an early review of oil-related mortality for seabirds, Dunnett et al. (1982) provided an estimate of 10 percent, and 60 percent of the dead birds may be recovered under typical field conditions. Piatt and Ford (1996: Table 1) summarized recovery rates from 17 carcass-drift experiments, indicating a range of 0-59 percent of carcasses being recovered. Using data from the *Exxon Valdez* oil spill, Piatt and Ford (1996) estimated recovery rates from joint probability and Monte Carlos simulations of only 8.0 percent and 6.9 percent, respectively.

Timing and location of the spill are the two primary factors for determining the severity of impacts on birds. The worst impacts to oiled birds or to those birds that have ingested oil with their prey would be if the oil spill occurs during the nesting season. An oil spill during nesting season could result in the loss of entire colonies of breeding birds on barrier islands surrounded by oil, along with the potential loss of all eggs and nestlings. Losses of shorebirds could occur through direct oiling of beaches on which nests are located, by oil covering the feeding sites near the nesting locations, or by the deaths of oiled parents, leaving eggs or hatchlings unprotected and unfed.

Endangered and Threatened Birds

Two species listed as endangered or threatened by the U.S. Fish and Wildlife Service that could be impacted by a catastrophic oil spill are the endangered least tern (*Sterna antillarum*) and the piping plover (*Charadrius melodus*). The Midwest Population of piping plovers, which nests along the Great Lakes, is listed as endangered while the Atlantic Coast and Northern Great Plains Populations are listed as threatened. The critical habitat for the plover is found within the wintering area which includes areas along the Gulf Coast from Texas to Florida (LeDee et al., 2008:Figure 1; Haig et al., 2005:Figure 1) where they feed on aquatic insects, invertebrates, and small crustaceans along the advancing and retreating water line of the beaches. Unknown numbers of piping plovers could therefore become oiled or have their feeding areas oiled if a spill occurred during the time of year, roughly October through March, when plovers are present (Haig et al., 2005: fig. 1, table 2). Least terns breed in isolated, smaller colonies along the Gulf Coast (primarily in Texas and Louisiana) and apparently in greater numbers at more inland riverine sites (e.g., Rio Grande River, Texas; Lower Mississippi River, Tennessee) (Kirsch and Sidle, 1999; Szell and Woodrey, 2003), so oiling that occurs during the nesting season could not only affect least tern feeding areas (least terns are piscivorous) but also cause oiling and loss of eggs and young.

4.2.2.2. Fish, Fisheries, and Essential Fish Habitat

Estuarine-dependent fish species spawn on the continental shelf. transport eggs, larvae, or juveniles back to the estuary nursery grounds, and the adults migrate back to the sea for spawning (Deegan, 1989; Beck et al., 2001). All of these estuaries in the GOM are extremely important nursery areas and considered EFH for fish and aquatic life (Beck et al., 2001). Oiling of these areas, depending on the severity, can destroy nutrient-rich marshes and erode coastlines that have been significantly damaged by recent hurricanes.

The Gulf of Mexico supports a wide variety of finfish, and most of the commercial finfish resources are linked either directly or indirectly to the estuaries that ring the Gulf of Mexico. Darnell et al. (1983) observed that the density distribution of fish resources in the Gulf was highest nearshore off of the central Gulf Coast. For all seasons, the greatest abundance occurred between Galveston Bay and the mouth of the Mississippi River. Monthly ichthyoplankton collections over the years 2004-2006 offshore of Alabama

have confirmed that peak seasons for ichthyoplankton concentrations on the shelf are spring and summer (Hernandez et al., 2010). Therefore, if a catastrophic blowout occurs in the spring and summer seasons, it could cause greater harm to fish populations, not just individual fish.

Oyster beds could be damaged by freshwater diversions that release tens of thousands of cubic feet of freshwater per second for months in an effort to keep oil out of the marshes. Adult oysters survive well physiologically in salinities from those of estuarine waters (about 7.5 parts per thousand sustained) to full strength seawater (Davis, 1958). While oysters may tolerate small changes in salinity for a few weeks, a rapid decrease in salinity over months would kill oysters. In the event of a catastrophic oil spill, the year's oyster production would be lost because of exposure to freshwater and/or oil. . . . Depending on the severity, oyster beds could take 2-5 years to recover (Burdeau, 2010).

4.2.2.3. Marine Mammals

Section 3.2.2 discusses the most likely and most significant impacts to the offshore marine mammal community. A high-volume oil spill lasting 120 days could directly impact almost 100 species of marine mammals. As the spill enters coastal waters, manatees and coastal and estuarine dolphins would be the most likely to be impacted.

Manatees primarily inhabit open coastal (shallow nearshore) areas and estuaries, and they are also found far up in freshwater tributaries. During warmer months, manatees are common along the Gulf Coast of Florida from the Everglades National Park northward to the Suwannee River in northwestern Florida, and they are less common farther westward. In winter, the Gulf of Mexico subpopulations move southward to warmer waters. The winter range is restricted to waters at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Manatees are infrequently found as far west as Texas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998). If a catastrophic oil spill reached the Florida coast when manatees were in or near coastal waters, the spill could have population-level effects.

It is possible that manatees could occur in coastal areas where vessels traveling to and from the spill site could affect them. A manatee present where there is vessel traffic could be injured or killed by a vessel strike (Wright et al., 1995). Due to the large number of vessels responding to a catastrophic spill both in coastal waters and traveling through coastal waters to the offshore site, manatees would have an increased risk of collisions with boats. Vessel strikes are the primary cause of death of manatees.

There have been no experimental studies and only a few observations suggesting that oil impacts have harmed any manatees (St. Aubin and Lounsbury, 1990). Types of impacts to manatees and dugongs from contact with oil include (1) asphyxiation due to inhalation of hydrocarbons, (2) acute poisoning due to contact with fresh oil, (3) lowering of tolerance to other stress due to the incorporation of sublethal amounts of petroleum components into body tissues, (4) nutritional stress through damage to food sources, and (5) inflammation or infection and difficulty eating due to oil sticking to the sensory hairs around their mouths (Preen, 1989, in Sadiq and McCain, 1993; Australian Maritime Safety Authority, 2003). For a population whose environment is already under great pressure, even a localized incident could be significant (St. Aubin and Lounsbury, 1990). Spilled oil might affect the quality or availability of aquatic vegetation, including seagrasses, upon which manatees feed. The 2009 Stock Assessment Report (USDOI, FWS, 2009) for the Florida stock of west Indian manatees estimates that there is a minimum population estimate of 3,802 individuals based on a single synoptic survey of warm-water refuges in January 2009. The manatee's potential biological removal (PBR) is the maximum number of animals, not including natural mortalities, that may be removed from the population or stock while allowing that stock to reach or maintain its optimum sustainable population and is approximately 12 individuals. Therefore, if a catastrophic spill and response vessel traffic occurred near manatee habitats in the eastern Gulf of Mexico, population level impacts could occur, because the possibility exists for the number of mortalities to exceed PBR.

Bottlenose dolphins were the most affected species of marine mammals from the *Deepwater Horizon* oil spill. Ninety to 96 dolphins were collected; 4 bottlenose dolphins were alive, 86 were dead. (The other species of dolphin affected from the *Deepwater Horizon* spill was spinner dolphins). Bottlenose dolphins can be found throughout coastal waters in the Gulf of Mexico. Like manatees, dolphins could be affected, possibly to population level, by a catastrophic oil spill if it reaches the coast (as well as affecting them in

the open ocean), through direct contact, inhalation, ingestion, and stress, as well as through collisions with cleanup vessels.

4.2.2.4. Sea Turtles

Out of the five species of sea turtle that occur in the Gulf of Mexico, only three nest in this area. The largest nesting location for the Kemp's ridley sea turtle is in Rancho Nuevo, Mexico, but they also nest in Texas. Loggerhead sea turtles nest in all states around the Gulf of Mexico. There are also records of nesting colonies of hawksbill sea turtles in the Yucatan Peninsula of Mexico (Plotkin et al., 1995). Kemp's ridley, loggerhead, and hawksbill sea turtles are therefore most likely to be affected by a catastrophic oil spill when there is onshore contact.

Female sea turtles emerge during the warmer summer months to nest Seasonally, females must emerge periodically from the ocean to nest on beaches. Thousands of sea turtles nest along the Gulf Coast, and turtles could build nests on oiled beaches. Nests could also be disturbed or destroyed by cleanup efforts. Untended booms could wash ashore and become a barrier to sea turtles adults and hatchlings (USDOC, NOAA, 2010e). Hatchlings, with a naturally high mortality rate, could walk through oiled sand and swim through oiled water to reach preferred habitats of sargassum floats. Response efforts could include mass movement of eggs from hundreds of nests or thousands of hatchlings from Gulf Coast beaches to the east coast of Florida or to the open ocean to prevent hatchlings entering oiled waters (Jernelöv and Lindén, 1981; USDOI, FWS, 2010e). Due to poorly understood mechanisms that guide female sea turtles back to the beaches where they hatched, it is uncertain if relocated hatchlings would eventually return to the Gulf Coast to nest (Florida Fish and Wildlife Conservation Commission, 2010). Therefore, shoreline oiling and response efforts may affect future population levels and reproduction (USDOI, NPS, 2010). Sea turtle hatchling exposure to, fouling by, or consumption of tarballs persisting in the sea following the dispersal of an oil slick would likely be fatal.

4.2.2.5. Terrestrial Mammals and Reptiles

Beach Mice

Seven subspecies of the field mouse, collectively known as beach mice, live along the Gulf Coast. Five subspecies of beach mice (Alabama, Perdido Key, Choctawhatchee, St. Andrew, and Anastasia Island) are listed as State and federally endangered; the southeastern beach mouse is listed as federally threatened; and the Santa Rosa beach mouse is a Federal species of concern. Beach mice are restricted to the coastal barrier sand dunes along the Gulf Coast of Alabama and Florida. Erosion caused by the loss of vegetation due to oiling would likely cause more damage than the direct oiling of beach mice, due to degradation or loss of habitat. In addition, vehicular traffic and activity associated with cleanup can trample or bury beach mice nests and burrows or cause displacement from preferred habitat. Improperly trained personnel and vehicle and foot traffic during shoreline clean up of a catastrophic spill would disturb beach mouse populations and would degrade or destroy habitat.

The Alabama, Choctawhatchee, St. Andrew, and Perdido Key beach mice are already designated as protected species under the Endangered Species Act (ESA) because of the loss of coastal habitat (USDOI, MMS, 2007). The species' coastal habitat is designated as their critical habitat. For example, the endangered Alabama beach mouse's (*Peromyscus polionotus ammobates*) habitat is 1,211 acres of frontal dunes covering just 10 miles of shoreline designated as critical habitat (USDOI, FWS, 2007). Critical habitat is the specific geographic areas that are essential for the conservation of a threatened or endangered species. With the potential oiling of over 1,000 miles of shoreline, the entire critical habitat for a subspecies of beach mice could be completely oiled. Thus, destruction of the remaining habitat due to a catastrophic spill and cleanup activities would increase the threat of extinction of several subspecies of beach mice.

Diamondback Terrapin

The Texas diamondback terrapin (*Malaclemys terrapin littoralis*) and the Mississippi diamondback terrapin (*Malaclemys terrapin pileata*) are two subspecies of terrapin that occur in the Gulf of Mexico

andare Federal species of concern. The former's range runs from Louisiana through Texas, while the latter's includes Louisiana, Mississippi, Alabama, and Florida (USDOI, FWS, 2010f). Terrapins inhabit brackish waters including coastal marshes, tidal flats, creeks, and lagoons behind barrier beaches (Hogan, 2003). Their diet consists of fish, snails, worms, clams, crabs, and marsh plants (Cagle, 1952). Spending most of their lives at the aquatic-terrestrial boundary in estuaries, terrapins are susceptible to habitat destruction from oil spill cleanup efforts as well as direct contact with oil. However, most impacts cannot be quantified at this time. Even after the oil is no longer visible, terrapins may still be exposed while they forage in the salt marshes lining the edges of estuaries where oil may have accumulated under the sediments and within the food chain. Terrapin nests can also be disturbed or destroyed by cleanup efforts. Chronic effects from oil contact including lethal or sublethal oil-related injuries, such as . . . may persist through the generations, potentially reducing population levels.

4.2.2.6. Coastal Habitats

A spill from a catastrophic blowout lasting up to 120 days could impact over 1,000 miles of shoreline. Shoreline oiling would vary between heavy, moderate, light, and occasional tarballs. Due to the length of shoreline that could potentially be oiled and the sensitivity of the Gulf Coast, a high-volume, extended-duration spill could cause extensive habitat degradation. Loss of vegetation could lead to erosion and permanent landloss.

In some previous spills reviewed, a strong storm removed the majority of oil from shore. However, storm surges may carry oil into the coastline and inland as far as the surge reaches. In addition, four significant hurricanes (Katrina, Rita, Gustav, and Ike) have made landfall along the Texas/Louisiana coast in the last 5 years, greatly degrading the coastal beaches, marshes, and barrier islands, making them more susceptible to a catastrophic spill.

Coastal Barrier Beaches and Associated Dunes

Barrier islands make up more than two-thirds of the northern Gulf of Mexico shore. Each of the barrier islands is either high profile or low profile, depending on the elevations and morphology of the island (Morton et al., 2004). The distinguishing characteristics of the high and low profile barriers relates to the width of the islands along with the continuity of the frontal dunes. Low profile barriers are narrow with discontinuous frontal dunes easily overtopped by storm surge which makes the island susceptible to over wash and secondarily to erosion. This over wash can create channels to bring sand onto the island or into lagoons formed on these islands. High profile barriers islands are generally wider than the low profile islands and have continuous, vegetated, frontal dunes with elevations high enough to prevent over wash from major storm surge and therefore are less susceptible to erosion. The sand stored in these high profile dunes allows the island to withstand prolonged erosion and therefore prevent breaching which could result in damaging the island core.

As a result of a catastrophic spill, many of the barrier islands and beaches would receive varying degrees of oiling. Oil disposal on sand and vegetated sand dunes would have little deleterious effects on the existing vegetation or on the recolonization of the oiled sands by plants (Webb, 1988). The depth of oiling would be variable, based on the wave environment and sediment source at a particular beach head. Layering of oil and sand could occur if it was not cleaned before another tidal cycle. However, most areas of oiling are expected to be light and sand removal during cleanup activities should be minimized. In areas designated as natural wilderness areas e.g., Breton National Wildlife National Refuge and Gulf Islands National Seashore land managers may require little to no disruption of the natural system. In these environments it is preferred to let the oil degrade naturally without aggressive and intrusive cleanup procedures. Manual rather than mechanized removal techniques will be used in these areas and only if heavy oiling has occurred. The exceptions occur in areas designated as natural wilderness areas (e.g., Breton National Wildlife National Refuge and Gulf Islands National Seashore) where the land managers want as little disruption to the "natural" system as possible. Thus, these areas may not be treated as thoroughly as other shorelines.

Once oil has reached the beaches and barrier islands and becomes buried or sequestered, it becomes difficult to treat. During wave events when the islands and beaches erode, the oil can become remobilized and transported. Thus, the fate of oil is not as simple as either reaching land, becoming sequestered or

being treated, but must be considered in terms of a continuing process of sequestration, remobilization, and transport.

For spilled oil to move onto beaches or across dunes, strong southerly winds must persist for an extended time prior to or immediately after the spill to elevate water levels. Strong winds, however, would reduce the impact severity at a landfall site because they would accelerate the processes of oil-slick dispersal, spill spreading, and oil weathering.

Due to the distance of beaches from deepwater blowout and the combination of weathering and dispersant treatment of the oil offshore, the toxicity of the oil reaching shore should be greatly reduced, thereby minimizing the chances of irreversible damage to the impacted areas. A blowout in shallower waters near shore may have equal or greater impacts due to a shorter period of weathering and dispersion prior to shoreline contact, even though a smaller volume of spilled oil is expected.

Vessel traffic in close proximity to barrier islands has been shown to move considerably more bottom sediment than tidal currents, thus increasing coastal and barrier island erosion rates. If staging areas are in close proximity to these islands, recovery time of the barrier islands could be greatly extended due to the magnitude of vessels responding to a catastrophic spill.

Wetlands

Coastal wetland habitats in the Gulf of Mexico occur as bands around waterways, broad expanses of saline, brackish, and freshwater marshes, mud and sand flats, and forested wetlands of cypress-tupelo swamps and bottomland hardwoods. A spill from a catastrophic blowout could oil a few to several hundreds of acres of wetlands depending on the depth of inland penetration (Burdeau and Collins, 2010). This would vary from moderate to heavy oiling.

The NOAA Environmental Sensitivity Index (ESI) ranks shorelines according to their sensitivity to oil, the natural persistence of oil, and the expected ease of cleanup after an oil spill. These factors cause oil to persist in coastal and estuarine areas (DOI, MMS, 2010). According to the ESI, the most sensitive shoreline types (i.e., sheltered tidal flats, vegetated low banks, salt/brackish-water marshes, freshwater marshes/swamps, and scrub-shrub wetlands) tend to accumulate oil and are difficult to clean, thus causing oil to persist in these coastal and estuarine areas (USDOI, MMS, 2010).

Precautions such as oil booms, skimmer ships, and barge barriers would be deployed to protect the beaches and the wetlands behind them or on the beach fringe from oil. However, if not maintained, these booms can cause significant harm to fragile wetlands. In most cases, the beach face would take the most oil; however, in areas where the marsh is immediately adjacent to the beach face or embayments, or in the case of small to severe storms, marshes would be oiled. For example, in Alabama, Mississippi and Florida, severe weather could push oil into the tidal pools and back beach areas that support tidal marsh vegetation.

Previous studies of other large spills have shown that when oil has a short residence time in the marsh and it is not incorporated into the sediments, the marsh vegetation has a good chance of survival, even though aboveground die-off of marsh vegetation may occur (Mendelssohn et al., 2002). However, if reoiling occurs after the new shoots from an initial oiling are produced, such that the new shoots are killed, then the marsh plants may not have enough stored energy to produce a second round of new shoots. Longer term damage may result from continued reoiling than from a temporally continuous oiling (Lin et al, 2002; Lin and Mendelssohn, 2009). Other studies noted the utilization of dispersants in the proper dosages results in a reduction in marsh damage from oiling (Lin and Mendelssohn, 2009).). The works of several investigators (Webb et al., 1981 and 1985; Alexander and Webb, 1983 and 1987; Lytle, 1975; Delaune et al., 1979; Fischel et al., 1989) evaluated the effects of potential spills to area wetlands. For wetlands along the central Louisiana coast, the critical oil concentration is assumed to be 0.025 gallon per ft^2 (1.0 liter per m^2) of marsh. Concentrations less than this may cause diebacks for one growing season or less, depending upon the concentration and the season during which contact occurs. The duration and magnitude of a spill resulting from a catastrophic blowout could result in concentrations above this critical level and would result in longer-term effects to wetland vegetation, including some plant mortality and loss of land.

Due to the distance of deep water from shore, the possibility of a spill from a deepwater blowout reaching coastal wetlands with the toxicity to significantly impact the coastal wetlands is low due to the response procedures implemented during a catastrophic spill. The utilization of nearshore booming

protection for beaches and wetlands, in combination with offshore skimming, burning, and dispersal treatments for the oil near the spill site, would result in capture and detoxification of the majority of oil reaching shore. Therefore, a spill from a shallow-water blowout is more likely to contribute to wetland damage.

The impact of oil cleanup can result in additional impacts to wetlands, if not done properly. Aggressive onshore and marsh cleanup methods have not yet been utilized and probably would not be initiated until the oil spill has been stopped. Depending on the marsh remediation methods used, further impacts to the wetlands may occur from cleanup activities.

Submerged Vegetation

Approximately 500,000 hectares (1.25 million acres) of submerged seagrass beds are estimated to exist in exposed, shallow coastal waters and embayments of the northern Gulf of Mexico, and over 80 percent of this area is in Florida Bay and Florida coastal waters (Beck et al., 2006; Carlson and Madley, 2006). Submerged vegetation distribution depends on an interrelationship between a number of environmental factors that include temperature, water depth, turbidity, salinity, turbulence, and substrate suitability (Sheridan and Minello, 2003). Marine seagrass beds generally occur in shallow, relatively clear, protected waters with predominantly sand bottoms (Short et al., 2001). Freshwater submerged aquatic vegetation (SAV) species occur in the low-salinity waters of coastal estuaries (Castellanos and Rozas, 2001). Seagrasses and freshwater SAVs provide important habitat for immature shrimp, black drum, spotted sea trout, juvenile southern flounder, and several other fish species and provide a food source for species of wintering waterfowl (Castellanos and Rozas, 2001; Short et al., 2001; Caldwell, 2003). These areas would have considerable impact from various cleanup efforts, such as increased vessel traffic. Although many of the beds are protected by extensive barrier islands, severe storms can cause inundation and overwashing of these islands, resulting in oiling of the seagrass beds if the storm occurred during an oil spill. In addition, boom anchors could damage seagrass beds (USDOC, NOAA, 2010e). It is assumed that there would be a decrease in submerged vegetation and a negative impact on the bed communities in a highly affected area. If bays and estuaries accrue oil, there is an assumption that there would be a decrease in seagrass cover and negative community impacts. Depending on the species and environmental factors, seagrasses may exhibit minimal impacts from a spill; however, communities within the beds could accrue greater negative outcomes (Jackson et al., 1989; Taylor et al., 2006). Community effects could range from direct mortality due to smothering or indirect mortality from loss of food sources and loss of habitat due to a decrease in ecological performance of the entire system (Zieman et al., 1984).

4.2.3. Socioeconomic Resources

4.2.3.1. Onshore Archaeological Resources

Regardless of the water depth in which the catastrophic blowout occurs, it is assumed that more than 1,000 miles of shoreline could be oiled to some degree. Onshore prehistoric and historic sites would be impacted to some extent by a high-volume spill from a catastrophic blowout that reaches shore. Sites on barrier islands could suffer the heaviest impact (McGimsey, personal communication, 2010). A few prehistoric sites in Louisiana, located inland from the coastline in the marsh and along bayous, could experience some light oiling. As discussed above, impacts would include the loss of ability to accurately date organic material from archeological sites due to contamination. Efforts to prevent coastal cultural resources from becoming contaminated by oil would likely be overwhelmed in the event of a hurricane and by the magnitude of shoreline impacted. The most significant damage to archaeological sites could be related to cleanup and response efforts. Fortunately, important lessons were learned from the *Exxon Valdez* spill in Alaska in 1989, in which the greatest damage to archaeological sites was related to cleanup activities and looting by cleanup crews rather than from the oil itself (Bittner, 1996). As a result, cultural resources were recognized as significant early in the response, and archaeologists are, at present, embedded in Shoreline Cleanup Assessment Teams (SCAT) and are consulting with cleanup crews. Historic preservation representatives are present at both the Joint Incident Command as well as each Area Command under the general oversight of the National Park Service to coordinate response efforts (Odess, personal communication, 2010). Despite these efforts, some archaeological sites suffered damage from

looting or from spill clean-up activities (most notably the parade ground at Fort Morgan) (Odess, personal communication, 2011).

4.2.3.2. Commercial Fishing

In addition to closures in Federal waters, portions of individual State waters would also be closed to commercial fishing. The economic impacts of closures on commercial fishing are complicated to predict because it is dependent on season and would vary by fishery. If fishers cannot make up losses in the remainder of the season, a substantial part of their annual income will be lost. In some cases, commercial fishers may move to areas still open to fishing, but at a greater cost due to longer transits.

4.2.3.3. Recreational Fishing

In addition to closures in Federal waters, portions to of individual State waters would also be closed to recreational fishing. More than 67 percent of the total Gulf catch came on trips that fished primarily in inland waters (Pritchard, 2009). In 2008, over 24 million recreational fishing trips were taken, which generated about $12 billion in sales, over $6 billion in value added impacts, and over 100,000 jobs (USDOC, NOAA, NMFS, 2010b). The majority of recreational fishing occurs in the summer months. During this time, scheduled fishing tournaments are held and would be hard to reschedule. If the spill affected the summer months, normal direct income and indirect income to the communities that host these tournaments would be lost for that year. If a catastrophic spill occurs in the summer, the majority of recreational fishing trips would not occur and economic benefits they generate would be lost for that year.

4.2.3.4. Tourism and Recreational Resources

Tourism and recreation are integral components of the economy of the Gulf of Mexico. Visitors to Texas, Louisiana, Mississippi, Alabama, and Florida spent approximately $145 billion in 2008. (U.S. Travel Association (2008)). This spending helped to support approximately 2.4 million jobs in recreation-based industries statewide (U.S. Dept. of Labor, 2010a). Roughly 600,000 of these jobs are in counties that are directly along the coast, making them particularly vulnerable to a catastrophic event and the likely associated decrease in tourism. Recreation jobs account for 14.8 percent of Gulf Coast employment, greater than the national average of 12.4 percent (QCEW Fact Sheet). The coastal counties and parishes that have the highest concentration of recreation workers (over 10,000 workers) in each state are as follows: Cameron, Nueces, and Galveston Counties (Texas); Jefferson and Orleans Parishes(Louisiana); Harrison County (Mississippi); Mobile and Baldwin Counties (Alabama); and Escambia, Okaloosa, Bay, Pasco, Pinellas, Hillsborough, Manatee, Sarasota, Lee, Collier, Broward, and Miami-Dade Counties (Florida). Gulf Coast recreational employment is reasonably cyclical, with the peak months during the past few years occurring between March and June (U.S. Dept. of Labor, 2010b).

A catastrophic spill has the potential to significantly impact the Gulf Coast recreation and tourism industries. The water-dependent and beach-dependent components of these industries would be particularly vulnerable. This is particularly true for some of the nature parks and island resources directly along the coast, such as Padre Island National Seashore (Texas), Dauphin Island (Alabama), and the Gulf Islands National Seashore (Mississippi/Florida). Kaplan and Whitman (2008) attempt to isolate the economic significance of the recreational resources in the Gulf of Mexico that are particularly relevant to OCS oil and gas activities. They found roughly 60,000 jobs that were dependent on these activities in 2005, although there is uncertainty with this estimate, due to measurement issues and due to events that have occurred since their data collection period (most notably Hurricane Katrina).

In analyzing the potential impacts of a catastrophic spill, one must also consider the range of activities that depend on the base resources that may be affected. For example, the restaurant and lodging industries are particularly important to the Gulf economy. They are also sensitive to general tourism trends in any particular area. However, the economic impacts on these sectors from a spill may be partially offset due to an influx of cleanup and relief workers. Finally, one should consider the economic context in which a catastrophic event occurs. The *Deepwater Horizon* incident occurred in the context of an economy that was only beginning to recover from a very deep recession. In difficult economic times, recreation workers may be more prone to being laid off in response to a catastrophic event. Workers may also find it more difficult to transition between jobs, which can increase the severity of the economic effects. In a

recession, tourism also may be more sensitive both to actual damage and to perceptions of economic problems within a region.

4.2.3.5. Employment and Demographics

By the end of a catastrophic spill, up to 50,000 personnel would be expected to respond to protect the shoreline and wildlife and to cleanup vital coastlines. The degree to which new cleanup jobs offset job losses would vary greatly from county to county (or parish to parish). However, these new jobs would not make up for lost jobs, in terms of dollar revenue. In most cases, cleanup personnel are paid less (e.g., $15-$18 an hour compared with roughly $45 an hour on a drilling rig), resulting in consumers in the region having reduced incomes overall and thus, investing less money in the economy (Aversa, 2010). Permanent demographic impacts are unlikely from these temporary jobs.

There would be additional economic impacts to tourism and both recreational and commercial fishing, as discussed in Sections 4.2.3.2 through 4.2.3.4 above.

4.2.3.6. Land Use and Coastal Infrastructure

In the event of a catastrophic spill, impacts on land use and infrastructure would be temporary and variable in nature. These impacts include land use in staging areas, waste disposal locations and capacities, and potential delays due to vessel decontamination stations near ports, as described below.

Up to 20 staging areas and as many as 50,000 responders would likely result in increased traffic congestion and some possible competing land use issues near the staging areas, depending on the real estate market at the time of the event. Some infrastructure categories, such as vessels, ports, docks and wharves would likely become very engaged in response activities and this could result in a shortage of space and functionality at infrastructure facilities if ongoing drilling activities were simultaneously occurring. However, if a drilling suspension was enacted, like the *Deepwater Horizon* incident, conflicting demands on infrastructure facilities would likely fail to materialize (Dismukes, personal communication, 2010a).

In the category of waste disposal, the impacts would be more visible as thousands of tons of oily liquid and solid wastes from the oil-spill cleanup are disposed of in onshore landfills. The USEPA the U.S. Coast Guard would likely issue solid waste management directives to address the issue of contaminated materials and solid or liquid wastes that are recovered as a result of cleanup operations (USEPA, 2010d and 2010e).

For navigation and port use, there is also the potential for delays in cargo handling and slow vessel traffic due to decontamination operations at various sites along the marine transportation system (USDOT, 2010). However, most cleanup activities would be complete within a year of the event, so impacts would be expected to be limited in duration (Dismukes, personal communication, 2010b).

4.2.3.7. Environmental Justice

While most coastal populations of along the Gulf of Mexico coast are not generally minority or low income, several communities on the coasts of St. Mary, Lafourche, Terrebonne, St. Bernard, and Plaquemines Parishes have minority or low-income population percentages that are higher than their respective state averages. are predominately Native American, Islaños, or African American. For example, a few counties or parishes along the Gulf Coast have more than a 2-percent Native American population (USDOI, MMS, 2007); about 2,250 Houma Indians (a State of Louisiana recognized tribe) are concentrated in Lafourche Parish, Louisiana comprising 2.4% of the parish's population, and about 800 Chitimacha (a federally recognized tribe) make up 1.6% of St. Mary Parish's population. While these aren't significant numbers on their own, viewed in the context of Louisiana's overall 0.6 percent Native American average, these communities take on greater environmental justice importance.

Gulf Coast minority and low-income groups are particularly vulnerable to the coastal impacts of a catastrophic oil spill due to their dependence on the natural resources in the offshore and coastal environments. Besides their economic reliance on commercial fishing and oystering, coastal low-income and minority groups rely heavily on these fisheries and other traditional subsistence fishing, hunting, trapping, and gathering activities to augment their diets and household incomes (see Hemmerling and Colton, 2003, for an evaluation of environmental justice considerations for south Lafourche Parish).

Regular commuting has continued this reliance on the natural resources of the coastal environments even when populations have been forced to relocate because of landloss and the destruction from recent hurricane events.

State fishery closures due to a catastrophic oil spill would disproportionately affect minority and low-income groups. Shoreline impacts would generate additional subsistence-related effects. Therefore, these minority groups would be disproportionately affected if these coastal areas were impacted by a catastrophic spill and the resulting response.

5. POST-SPILL, LONG-TERM RECOVERY (PHASE 4)

5.1. Impact-Producing Factors and Scenario

During the final phase a catastrophic blowout and spill, it is presumed that the well has been capped or killed and cleanup activities are concluding. While it is assumed that the majority of spilled oil would be dissipated within 30 days of stopping the flow (Inter-agency, 2010a), oil has the potential to persist in the environment long after a spill event and has been detected in sediment 30 years after a spill (USDOI, FWS, 2004). On sandy beaches, oil can sink deep into the sediments. In tidal flats and salt marshes, oil may seep into the muddy bottoms (USDOI, FWS, 2010g).

5.2. Most Likely and Most Significant Impacts

At this point in the scenario, the spill has been stopped and long-term recovery begins. There is a great deal of uncertainty regarding the long-term impacts of a catastrophic spill in the Gulf of Mexico. The most likely and most significant impacts, as described below, will likely relate to the continued exposure of organisms to the spilled oil, oil components, and dispersants remaining in the air, water, and sediments, as well as the effects of continued cleanup efforts.

A catastrophic spill can have long-term impacts on Gulf of Mexico ecosystems. An ecosystem is a geographically specified system of organisms, including humans, their environment, and the processes that control their dynamics. Ecosystems involve complex connections between organisms, their environment, and the processes that drive the system (USDOC, NOAA, 2010f). In some cases, marine ecosystems may take decades to fully recover or may recover to alternative states (Ragen, 2010).

5.2.1. Physical Resources

5.2.1.1. Air Quality

There would be some residual air quality impacts after the well is capped or “killed”. As most of the oil would have been burned, evaporated, or weathered over time, air quality would return to pre-oil spill conditions. While impacts to air quality are expected to be localized and temporary, as discussed in Sections 2.2.1.1, 3.2.1.1, and 4.2.1.1, adverse effects that may occur from the exposure of humans and wildlife to air pollutants could have long-term consequences.

5.2.1.2. Coastal and Offshore Water Quality

The leading source of contaminants that impairs coastal water quality in the Gulf of Mexico is urban runoff. Urban runoff can include suspended solids, heavy metals, pesticides, oil, grease, and nutrients (such as from lawn fertilizer). Urban runoff increases with population growth, and the Gulf Coast region has experienced a 103 percent population growth since 1970 (USDOC, NOAA, NOS, 2008). Other pollutant source categories include (1) agricultural runoff, (2) municipal point sources, (3) industrial sources, (4) hydromodification (e.g., dredging), and (5) vessel sources (e.g., shipping, fishing, and recreational boating). The NRC (2003; Table I-4, p. 237) estimated that, on average, approximately 26,324 barrels of oil per year entered Gulf waters from petrochemical and oil refinery industries in Louisiana and Texas. The Mississippi River introduced approximately 3,680,938 barrels/year (NRC, 2003; Table I-9, p.242) into the waters of the Gulf. Hydrocarbons also enter the Gulf of Mexico through the result of natural seeps in the Gulf of Mexico at a rate of approximately 980,392 barrels per year (a range of approximately 560,224-1,400,560 barrels/year) (NRC, 2003; p. 191). Produced water (formation

water) is, by volume, the largest waste stream from the oil and gas industry that enters Gulf waters. The NRC has estimated the quantity of oil in produced water entering the Gulf per year to be 473,000 bbl (NRC, 2003; p. 200, Table D-8).[2] These sources total about 5.5 million barrels of oil per year that routinely enters Gulf of Mexico waters. In comparison, a catastrophic spill of 30,000-60,000 barrels per day for 90-120 days would spill a total of 2.7-7.2 million barrels of oil. When added to the other sources of oil listed above, this would result in a 48- to 129-percent increase in the volume of oil entering the water during the year of the spill. In addition, the oil from a spill will be much more concentrated in some locations than the large number of other activities that release oil into the Gulf of Mexico. Section 3.1.4. of this document discusses the properties and persistence of oil in the environment.

5.2.2. Biological Resources

As described below, long-term consequences on biological resources can include impaired reproduction, which can potentially impact population levels. Oil has the potential to persist in the environment long after a spill event and has been detected in sediment 30 years after a spill (FWS, 2004). On sandy beaches, oil can sink deep into the sediments. In tidal flats and salt marshes, oil may seep into the muddy bottoms. Oil in these systems has the potential to have long-term impacts on fish and wildlife populations.

Some animals may survive initial exposure to spilled oil but may accumulate high levels of contaminants in their bodies that can be passed on to predators, in a process known as bioaccumulation (USDOI, FWS, 2010g).

5.2.2.1. Coastal and Marine Birds

There is a high probability of underestimating the impacts of oil spills on avian species potentially encountering oil, particularly seabirds. Often overlooked and understudied are the long-term, sublethal, chronic effects due to sublethal exposure to oil. These effects may persist for years after exposure, reducing the capacity of affected individuals within the population to recover, due to effects that may range from minor physiological disorders through damage to vital organs (i.e., liver and kidney) (Alonso-Alvarez et al., 2007). Sublethal effects of oil could ultimately result in reductions in long-term survival or lower reproductive success for some species of birds (Fry et al., 1986; Leighton, 1993; Esler et al., 2000; Golet et al., 2003; Velando et al., 2010). In addition, even light oiling of avian eggs transferred via contact with contaminated breast feathers from an incubating female can be toxic to developing embryos (Albers, 1980; Albers and Heinz, 1983). Effects such as delayed sexual maturity of most seabird species, loss of breeding-age individuals, particularly females, may have long-term, population-level effects. Long-term, sublethal, chronic effects may exceed immediate losses due to direct mortality (i.e., oiled birds) if such residual effects influence a significant proportion of the population or disproportionately impact an important population segment (Newton, 1998; Peterson et al., 2003; Alonso-Alvarez et al., 2007).

5.2.2.2. Fish, Fisheries, and Essential Fish Habitat

In addition to possible small fish kills due to direct impacts (as described under Phases 2 and 3), a catastrophic spill could affect fish populations in the long term. Due to a catastrophic spill, a significant portion of a year class of fish could be absent from the following year’s fishery, reducing overall population numbers. However, sublethal impacts, especially for long-lived species (e.g., snapper and grouper), could be masked by reduced fishing pressure due to closures. In addition, healthy fish resources and fishery stocks depend on ideal habitat (EFH) for spawning, breeding, feeding, and growth to maturity. Thus, a catastrophic spill that affects these areas could result in long-term impacts, including destruction to a portion of their habitats.

[2] These numbers were generated from converting the units reported in the noted reference and do not imply any level of significance.

5.2.2.3. Marine Mammals

Even after the spill is stopped, oilings or deaths of marine mammals would still likely occur due to oil and dispersants persisting in the water, past marine mammal/oil or dispersant interactions, and ingestion of contaminated prey. The animals' exposure to hydrocarbons persisting in the sea may result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity; and increased vulnerability to disease) and some soft tissue irritation, respiratory stress from inhalation of toxic fumes, food reduction or contamination, direct ingestion of oil and/or tar, and temporary displacement from preferred habitats or migration routes. These long-term impacts could have population-level effects (USDOC, NOAA, NMFS, 2010c).

5.2.2.4. Sea Turtles

Sea turtles take many years to reach sexual maturity. Green sea turtles reach maturity between 20 and 50 years of age; loggerheads may be 35 years old before they are able to reproduce; and hawksbill sea turtles typically reach lengths of 27 inches for males and 31 inches for females before they can reproduce (USDOC, NOAA, NMFS, 2010d). In most foreseeable cases, exposure to hydrocarbons persisting in the sea following the dispersal of an oil slick would result in sublethal impacts (e.g., decreased health, reproductive fitness, and longevity and increased vulnerability to disease) to sea turtles. As discussed in Section 4.2.2, shoreline oiling and response efforts may affect future population levels and reproduction (USDOI, NPS, 2010). The deaths of subadult and adult sea turtles may also drastically reduce the population.

5.2.2.5. Terrestrial Mammals and Reptiles

Beach Mice

Within the last 20-30 years, the combination of habitat loss due to beachfront development, isolation of remaining beach mouse habitat areas and populations, and destruction of remaining habitat by tropical storms and hurricanes has increased the threat of extinction of several subspecies of beach mice. Destruction of the remaining habitat due to a catastrophic spill and cleanup activities would increase the threat of extinction.

Diamondback Terrapin

Habitat destruction, road construction, and drowning in crab traps are the most recent threats to diamondback terrapins. Tropical storms, hurricanes, and beach erosion threaten their preferred nesting habitats. Destruction of the remaining habitat due to a catastrophic spill and response efforts could drastically affect future population levels and reproduction.

5.2.2.6. Coastal Habitats

Coastal habitats serve important ecological functions, and the loss of vegetation in coastal areas could lead to erosion and permanent land loss.

Coastal Barrier Beaches and Associated Dunes

Oil or its components that remain in the sand after cleanup may be (1) released periodically when storms and high tides resuspend or flush beach sediments, (2) decomposed by biological activity, or (3) volatilized and dispersed.

The protection once afforded to inland marshes by coastal barrier beaches has been greatly reduced due to decreased elevations and the continued effect of subsidence, sea-level rise, and saltwater intrusion. A catastrophic spill has the potential to contribute to this reduction.

The cleanup impacts of a catastrophic spill could result in short-term (up to 2 years) adjustments in beach profiles and configurations as a result of sand removal and disturbance during cleanup operations. Some oil contact to lower areas of sand dunes is expected. These contacts would not result in significant

destabilization of the dunes. The long-term stressors to barrier beach communities caused by the physical effects and chemical toxicity of an oil spill may lead to decreased primary production, plant dieback, and hence further erosion.

Wetlands

Wetlands serve a number of important ecological functions. For example, Louisiana's coastal wetlands support more than two-thirds of the wintering waterfowl population of the Mississippi Flyway, including 20-25 percent of North America's puddle duck population. Therefore, loss of wetlands would also impact a significant portion of the waterfowl population.

The duration and magnitude of a spill resulting from a catastrophic blowout could result in high concentrations of oil that would result in long-term effects to wetland vegetation, including some plant mortality and loss of land. This would add to continuing impacts of other factors, such as hurricanes, subsidence, saltwater intrusion, and sea-level rise. The wetlands along the Gulf Coast have already been severely damaged by the 2005 and 2008 hurricane seasons, leaving the mainland less protected. It was estimated in 2000 that coastal Louisiana would continue to lose land at a rate of approximately 2,672 ha/yr (10 mi^2/yr) over the next 50 years. Further, it was estimated that an additional net loss of 132,794 ha (512 mi^2) may occur by 2050, which is almost 10 percent of Louisiana's remaining coastal wetlands (Barras et al., 2003). Barras (2006) indicated an additional 217 mi^2 (562 km^2) of land lost during the 2005 hurricane season. A catastrophic spill occurring nearshore would contribute further to this landloss. Following Hurricanes Katrina and Rita, another series of hurricanes (Gustav and Ike) made landfall along the Louisiana and Texas coasts in September 2008. Hurricane Gustav made landfall as a Category 2 storm near Cocodrie, Louisiana, pushing large surges of saline water into the fresh marshes and coastal swamps of Louisiana from Grand Isle westward. While Hurricane Gustav did not impact the quantity of wetlands that Hurricanes Katrina and Rita impacted, it did have a severe and continuing effect on the coastal barrier islands and the wetlands associated with backshore (back of the island) and foreshore (front of the island). While Hurricane Gustav affected the eastern portion of the Louisiana coast closer to Grand Isle and Houma, Hurricane Ike concentrated on Louisiana's western coast. The Texas coast received the brunt of Hurricane Ike where it made landfall slightly east of Galveston. The storm surge basically removed the dune systems and significantly lowered the beach elevations along the eastern portion of the Texas coast near Galveston and the Bolivar Peninsula. The erosion and wash-over associated with Ike's tidal surge breeched beach ridges opened the inland freshwater ponds and their associated wetlands to the sea. As a result of the four successive storms, the Louisiana and Texas coasts have lost protective elevations, barrier islands, and wetlands and they now have the potential for transitioning to a less productive salt-marsh system in areas where fresh-marsh systems once existed.

In addition, a poorly executed oil cleanup can result in additional impacts. Aggressive onshore and marsh cleanup methods have not yet been utilized and probably would not be initiated until the oil spill has been stopped. Depending on the marsh remediation methods used, further impacts to the wetlands may occur from cleanup activities. Boat traffic in marsh areas from the thousands of response vessels associated with a catastrophic spill would produce an incremental increase in erosion rates, sediment resuspension, and turbidity (i.e., an adverse but not significant impact to coastal wetland and seagrass habitats.)

5.2.2.7. Open Water Habitats

Submerged Vegetation

If bays and estuaries accrue oil, there is an assumption that there would be a decrease in seagrass cover and negative community impacts. Submerged vegetation serves important ecological functions. For example, seagrasses and freshwater SAVs provide important habitat for immature shrimp, black drum, spotted sea trout, juvenile southern flounder, and several other fish species, and they provide a food source for species of wintering waterfowl (Castellanos and Rozas, 2001; Short and Coles, 2001; Caldwell, 2003). Therefore, loss of submerged vegetation would impact these species.

Sargassum

Oceanographic processes that concentrate sargassum into mats and rafts would also concentrate toxic substances. Therefore, it may be assumed that sargassum would be found in areas where oil, dispersants, and other chemicals have accumulated following a catastrophic spill. The ultimate effects oftoxins to sargassum are unclear; however, it is evident that the accumulation provides a toxic environment for associated species, especially those that use the sargassum as areas of refuge for larvae or other developmental stages (Unified Incident Command, 2010d). There would be noticeable effects on species that eat the plant material, such as sea turtles, and the death rate of sargassum may be increased due to toxic substances, which would contribute to a major decline in its biomass. This would decrease available habitat for associated organisms and indirectly affect the survival rate and recruitment for associated fish species. The severity and duration of any toxic effects would be dependent on both the physical properties of the toxic components and their biological effects, such as how long it might take them to degrade, their solubility in water, and the degree that they accumulate in biological tissue.

5.2.2.8. Benthic Habitats

Shelf Habitats

In situations where soft-bottom infaunal communities are negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period. Recolonization would begin with recruitment and immigration of opportunistic species from surrounding stocks. More complex communities would follow with time. Repopulation could take longer for areas affected by direct oil contact in higher concentrations.

Hard-bottom communities exposed to large amounts of resuspended sediments following a catastrophic, subsurface blowout could be subject to sediment suffocation, exposure to resuspended toxic contaminants, and reduced light penetration. The greatest impacts would occur to communities that exist in clear water with very low turbidity. The consequences of a blowout along, directly on, or near one of these features could be long lasting, although the occurrence of a blowout near such sensitive communities is unlikely because NTL 2009-G39 prevents drilling activity near sensitive hard-bottom habitats. Impacts would more likely be from low level or long-term exposure. This type of exposure has the potential to greatly impact reef coral communities, resulting in impaired reef health. Impacts to a community in more turbid waters would be greatly reduced, as the species are tolerant of suspended sediments, and recovery would occur quicker.

Deepwater Soft-Bottom Benthic Communities

In situations where soft-bottom infaunal communities are negatively impacted, recolonization by populations from neighboring soft-bottom substrate would be expected over a relatively short period of time for all organisms ranging from a matter of days for bacteria and probably less than 1 year for most macrofauna and megafauna species. This could take longer for areas affected by direct oil contact in higher concentrations.

Deepwater Coral Benthic Communities

Deepwater corals are expected to be resistant to oiling, with little effect from low exposure. Many invertebrates associated with deepwater coral communities, particularly the crustaceans, would likely be more susceptible to damage from oil exposure. Recolonization of severely damaged or destroyed communities could take years to decades.

Deepwater Chemosynthetic Benthic Communities

While chemosynthetic communities that receive low quantities of well-dispersed oil undergoing biodegradation would likely experience little negative effect, recolonization of severely damaged or destroyed communities could take years to decades.

5.2.3. Socioeconomic Resources

5.2.3.1. Offshore and Onshore Archaeological Resources

While it is unlikely (Section 2.2.3.1), a known shipwreck could be impacted by the blowout itself or the subsequent oil spill, impacts (i.e., contamination) from the release of large quantities of dispersants associated with a deepwater, catastrophic blowout are possible. Because a site cannot be avoided unless its location in known, undiscovered shipwrecks are at a much higher risk as a result of a blow out. Long-term effects of oiling of prehistoric and historic archaeological resources are poorly understood; however, damage to the protective layer of corals and other organisms on shipwreck sites by oiling could alter the surrounding site dynamics and increase their degradation. In addition, onshore habitat degradation could lead to erosion, which would increase exposure to and subsidence of prehistoric and historic sites. Unlike biological resources that have the potential to recover, damage to archaeological resources from the spill or cleanup activities would be irreversible, leading to loss of important archaeological data needed for proper study and interpretation. Archaeological sites also provide recreational opportunities both offshore and onshore; therefore, the loss of a site would also have impacts on recreation.

5.2.3.2. Commercial Fishing

The Gulf is an important biologic and economic area in terms of seafood production and recreational fishing. According to NOAA, there are 3.2 million recreational fishermen in the Gulf of Mexico region who took 24 million fishing trips in 2008. Commercial fishermen in the Gulf harvested more than 1 billion pounds of finfish and shellfish in 2008 (USDOC, NOAA, 2010g). The economic impacts of closures on commercial fishing are complicated to predict because the economic effects are dependent on season and would vary by fishery. If fishers cannot make up losses in the remainder of the season, a substantial part of their annual income could be loss. While the commercial fishing industry of Texas did not sustain measurable direct or indirect economic effects following the 1979 *Ixtoc* blowout and spill (Restrepo et al., 1982), there is a documented phenomenon that, long after an incident, the perception of tainted fish and shellfish from the impacted area persists (Keithly and Diop, 2001). It is reasonable to assume that a negative perception could impact the value of commercial fish resources for several seasons.

5.2.3.3. Recreational Fishing

In 2008, over 24 million recreational fishing trips were taken in the Gulf of Mexico, which generated about $12 billion in sales, over $6 billion in value added impacts, and over 100,000 jobs (USDOC, NOAA, NMFS, 2010b). Unlike commercial fishing, recreational fishing is concentrated during the summer months. Therefore, a catastrophic spill occurring at the beginning of the recreational fishing season and continuing through the season would result in the loss of millions of recreational fishing trips and billions in subsequent sales. For example, during the summer months, scheduled fishing tournaments are held that would be hard to reschedule. Normal direct income and indirect income to the communities that host these tournaments would be lost for that year.

5.2.3.4. Tourism and Recreational Resources

The longer-term implications of a catastrophic event on tourism would depend on the extent to which any structural/ecological damage can be repaired, as well as on the extent to which public confidence in the tourism industry can be restored. For example, a catastrophic oil spill would likely affect the fish populations in the affected waters to some extent. The most direct impact of this would be to lessen recreational fishing activity in a region to the extent that the fish population has decreased. However, a region would not fully recover from the event until confidence in fishing is restored and the remaining fish population recovers. In addition, restaurants in the region would be impacted to the extent to which they are perceived to use seafood products caught or raised in contaminated waters. Similarly, although beaches can be decontaminated not long after a spill has been stopped, lingering perceptions can be expected to negatively impact tourism.

Oxford Economics (2010) conducted a study of recent catastrophic events in order to estimate the longer-term economic implications of the *Deepwater Horizon* Oil Spill. They estimate that the long-term economic damage from the spill could be between $7.6 and $22.7 billion. Analyzing previous oil spills and other catastrophic events, they also suggest that it could take 15-36 months for the tourism industry to recover to pre-spill levels. Given Florida's dependence on fishing and beach activities (as well as the overall size of its economy), this study suggests that the State would bear the majority of the economic damage from the spill. This study also points out the complicated set of economic and psychological forces ultimately determine the extent to which the tourism and recreation industries would recover from a catastrophic oil spill.

5.2.3.5. Employment and Demographics

While a catastrophic spill could immediately impact several Gulf States for several months through fishing closures, loss of tourism, and any suspension of oil and gas activities, anticipating the long-term economic and employment impacts in the Gulf of Mexico is a difficult task. Many of the potentially affected jobs, like fishing charters, are self-employed. Thus, they would not necessarily file for unemployment and will not be included in business establishment surveys used to estimate State unemployment levels. In addition, unemployment numbers in states are based on nonagricultural jobs, and the fishing industry is considered within the agriculture category. On the other side, it is also a challenge to estimate how many of these displaced workers have been hired to clean up the spill. For example, while thousands of vessels of opportunity would be active in the spill response, not all of these would be displaced commercial fishermen from the affected areas. The positive employment impacts related to response activities are likely to be shorter term than the negative impacts discussed above.

Catastrophic spills have a huge regional economic impact, as seen recently in the *Deepwater Horizon* incident. It is estimated that the total economic consequences of the *Deepwater Horizon* incident will lead to a net loss of just under $20 billion for the U.S. economy in 2010, which would lower U.S. economic growth in 2010 by roughly 0.1 percent and would reduce growth to a greater extent in the four states most affected.

5.2.3.6. Land Use and Coastal Infrastructure

Based on the rapid recovery of infrastructure that was heavily damaged by the catastrophic 2005 hurricane season, there are not expected to be any long-term impacts to land use and coastal infrastructure as a result of a catastrophic oil-spill event. However, BOEMRE would continue to monitor the post-spill, long-term recovery phase of the *Deepwater Horizon* incident for any changes that indicate otherwise. A catastrophic spill could generate up to 60,000 tons of oil-impacted solid materials disposed in landfills along the Gulf Coast. This waste may contain debris, beach or marsh material (sand/silt/clay), vegetation, and personal protection equipment collected during cleanup activities. This would be equivalent to 2-6 years of waste produced from OCS oil and gas activities in the Gulf of Mexico (Dismukes et al., 2007). However, landfill capacity is not expected to be an issue at any phase of the oil-spill event or the long-term recovery. According to USEPA, existing landfills that are receiving oil-spill waste from the *Deepwater Horizon* incident have plenty of capacity to handle the expected waste volumes. The oil-spill waste that is being disposed in landfills represents less than 7 percent of the total daily waste normally accepted at these landfills (USEPA, 2010a).

It is not expected that any long-term, land-use impacts would arise from properties that are utilized for restoration activities and would somehow have their future economic use compromised. The rise or fall of property values would not be solely a function of some kind of economic impact from a catastrophic oil spill event. There are many other factors that influence the value of property and its best economic use. It is not clear from past experiences whether vegetation loss or erosion created by a spill could result in changes in land use. The amount and location of erosion and vegetation loss can be influenced by the time of year the spill occurs, its location, and weather patterns, including hurricane landfalls (Dismukes, personal communication, 2010a).

5.2.3.7. Environmental Justice

After the spill is stopped, the primary environmental justice concerns relate to possible long-term health impacts to cleanup workers, a predominately minority population, and to possible disposal of oil-impacted solid waste in predominantly minority areas.

Suspension of Oil and Gas Activities

An analysis of socioeconomic characteristics shows that people of Cajun ethnicity in the Gulf states, often found to be of a comparatively low socioeconomic status and work jobs in the textile and oil industries (Henry and Bankston, 1999). Past studies suggest that a healthy offshore petroleum industry also indirectly benefits low-income and minority populations (Tolbert, 1995). One BOEMRE study in Louisiana found income inequality decreased during the oil boom of the 1980’s and increased with the decline (Tolbert, 1995). Although we know that many oil- and gas-related service industries are cutting costs and putting off maintenance to defer massive layoffs in response to the oil-spill-caused deepwater drilling suspension and the slowed schedule for shallow-water drilling permits, we do not fully understand their long-term impacts.

Onshore and Offshore Cleanup Workers

By the end of a catastrophic spill, up to 50,000 personnel would be expected to be responding to the spill. The majority of these are field responders (United Incident Command, 2010f). As seen with the *Deepwater Horizon* incident, the racial composition of cleanup crews was so conspicuous that Ben Jealous, the president of the National Association for the Advancement of Colored People (NAACP), sent a public letter to BP Chief Operations Officer Tony Hayward on July 9, 2010, demanding to know why African Americans were over-represented in "the most physically difficult, lowest paying jobs, with the most significant exposure to toxins" (NAACP, 2010). While regulations require the wearing of protective gear and only a small percentage of cleanup workers suffer immediate illness and injuries (CDC, 2010), exposure could have long-term health impacts (e.g., increased rates of some types of cancer) (Savitz and Engel, 2010; Kirkeleit et al., 2008). Of the 38 accidents involving supertankers and resulting in large oil spills throughout the world, only seven studies on the repercussions of the exposure of spilled oils on human health have been completed. Aguilera et al. (2010) compiled and reviewed these studies for patterns of health effects and found evidence of the relationship between exposure and “acute physical, psychological, genotoxic, and endocrine effects in the exposed individuals.” Acute symptoms from exposure to oil, dispersants, and degreasers include headaches, nausea, vomiting, diarrhea, sore eyes, runny nose, sore throat, cough, nose bleeds, rash, blisters, shortness of breath, and dizziness (Sathiakumar, 2010). USEPA monitoring data has so far shown that the use of dispersants during the DWH event did not result in a presence of chemicals that surpassed human health benchmarks (Trapido, Health Presentation, 2010). Longitudinal epidemiological studies of possible long-term health effects from exposure to either the DWH event oil or dispersants, such as the possible bioaccumulation of toxins in tissues and organs, are lacking and potential for the long-term human health effects are largely unknown (although the National Institutes of Health has proposed such a study).

Prior research on post-spill cleanup efforts, found that the duration of cleaning work was a risk factor for acute toxic symptoms and that seamen had the highest occurrence of toxic symptoms compared to volunteers or paid workers. Therefore, participants in the DWH “Vessels of Opportunity” program, which recruited local boat-owners (including Cajun, Houma Indian, and Vietnamese fishermen) to assist in cleanup efforts, would likely be one of the most exposed groups. African Americans are thought to have made up a high percentage of the cleanup workforce. As seen with the *Deepwater Horizon* incident, the racial composition of cleanup crews was so conspicuous that Ben Jealous, the president of the National Association for the Advancement of Colored People (NAACP), sent a public letter to BP Chief Operations Officer Tony Hayward on July 9, 2010, demanding to know why African Americans were over-represented in “the most physically difficult, lowest paying jobs, with the most significant exposure to toxins” (NAACP, 2010). The Occupational Safety & Health Administration (OSHA) released two matrices of gear requirements for on- and off-shore Gulf operations that are organized by task (OSHA). Of past oil-spill workers, uninformed and poorly-informed workers were at more risk of exposure and

symptoms, demonstrating the importance of education and proper training of workers (Sathiakumar, 2010).

Therefore, a catastrophic spill could disproportionately affect seamen and onshore workers such as Cajuns, Vietnamese, Houma Indian, and African Americans.

During a recent National Institute of Environmental Sciences (NIEHS) workshop regarding the health effects of the BP *Deepwater Horizon* oil spill, Chairperson Nancy E. Adler pointed to the uncertainty regarding health effects and these types of events, "While studies of previous oil spills provide some basis for identifying and mitigating the human health effects of these exposures, the existing data are insufficient to fully understand and predict the overall impact of hazards from the *Deepwater Horizon* oil spill on the health of individuals—including workers, volunteers, residents, visitors, and special populations" (Institute of Medicine, 2010). In order to address these data gaps, NIEHS plans to begin a prospective study of the mental and physical health of about 50,000 workers who helped battle the spill.

Solid-Waste Disposal

Following a catastrophic spill, environmental justice concerns related to the disposal of cleanup-related wastes near minority and/or low-income communities (Schleifstein, 2010). It is estimated a catastrophic spill could generate up to 60,000 tons of oil-impacted solid materials that would be disposed in landfills along the Gulf Coast. While no new landfills would be built due to a catastrophic spill, the use of existing landfills might exacerbate existing environmental justice issues. For example, Mobile, Alabama and Miami, Florida are majority minority urban centers with a majority of minority residents living with a 1-mile radius of chosen landfills or liquid processing centers. While only a small percentage of DWH waste was sent to these facilities: 13% of liquid waste to Liquid Environmental Solutions in Mobile and only .28% of the total liquid waste to Cliff Berry in Miami, they could potentially receive more for future spills. For example, of the nine landfills approved by USEPA for oil-impacted solid materials, more than half of the waste was disposed in four landfills that were located in areas where minority groups comprised the majority of the population (Hernandez, 2010). Disposal procedures for the DWH event involved sorting waste materials into standard "waste stream types" at small, temporary stations, and then, sending each type to existing facilities that were licensed to dispose of them. The location of temporary sorting stations was linked to the location of containment and cleanup operations. Hence, future locations of any sorting stations are not predictable since they would be determined by the needs of cleanup operations. However, waste disposal locations were determined by the specializations of existing facilities and by contractual relationships between them and the cleanup and containment firms. Louisiana received about 82 percent of the DWH liquid waste recovered; of this, 56 percent was manifested to mud facilities located in Venice, Plaquemines Parish, Louisiana, and Port Fourchon, Lafourche Parish, Louisiana, and then transferred to a processing facility in Port Arthur, Texas. The waste remaining after processing was sent to deep well injection landfills located in Fannett and Big Hill, Texas. The sites located in Venice and Port Fourchon, Louisiana, and Port Arthur, Fannett, and Big Hill, Texas, have low minority populations but a few of these areas have substantial poverty rates relative to state and county means. Although, in the case of the DWH event, most of the cleanup occurred in the CPA, disposal occurred in both the CPA and WPA, and this would likely happen should a future event occur.

6. CUMULATIVE ENVIRONMENTAL AND SOCIOECONOMIC IMPACT

Like the recent, devastating hurricane seasons of 2005 and 2008, the *Deepwater Horizon* incident has changed the environmental baseline of the Gulf of Mexico. Another catastrophic oil spill would make the resources of the Gulf even more susceptible to further impacts, adding to the cumulative effects of an already sensitive ecosystem.

The Gulf Coast has survived major natural and manmade disasters (i.e., hurricanes and oil spills), through which the people and environmental resources of the Gulf of Mexico and the Gulf Coast have repeatedly demonstrated their resiliency. While environmental and socioeconomic resources may recover from a natural or manmade disaster if given enough time between disasters, disasters happening in unison or within short periods of each other would make recovery more difficult.

The magnitude of OCS and non-OCS activity in the Gulf of Mexico is so immense that routine activities associated with a single OCS oil and gas activity (e.g., single lease sale, single well) have a minor to no incremental contribution to the impacts of cumulative activities. However, a catastrophic blowout and spill would have a major contribution to cumulative impacts.

7. SUMMARY OF IMPACTS

7.1. SUMMARY OF IMPACTS FROM PHASE 1 (INITIAL EVENT)

The initial phase of the catastrophic event analyzed in the Gulf of Mexico is a blowout causing an explosion and fire, possibly resulting in the sinking of the drilling rig or platform. Impacts during Phase 1 would be limited to workers on the platform and environmental resources offshore in the immediate vicinity of the blowout. Air quality impacts include the emission of pollutants from the oil and the fire that are hazardous to human health and can possibly be fatal. Water quality impacts include localized water quality effects, which could include the release of a large amount of methane gas and the disturbance of a large amount of sediments over an extended area, if the blowout occurs outside the wellbore, below the seafloor.

An explosion would kill any birds resting on the platform, including birds protected under the Migratory Bird Treaty Act. Eruption of gases and fluids may generate significant pressure waves and noise to injure or kill individual animals in the vicinity, including federally listed threatened and endangered species under the ESA or MMPA. A shock wave under water may also impact commercial and recreational fisheries in the area. Benthic communities beyond avoidance zones could be smothered. In addition to a large number of fatalities and injuries of people on the drilling rig or platform itself, commercial and recreational fishers and divers near the blowout could be injured or killed. The blowout could also damage any unidentified archaeological sites nearby.

7.2. SUMMARY OF IMPACTS FROM PHASE 2 (OFFSHORE SPILL)

The second phase of the catastrophic event analyzed is an extended, offshore spill estimated to last 1-4 months for a blowout in shallow water and 3-5 months for a blowout in deepwater, due to more difficult intervention. A large-scale response effort would be expected for a catastrophic spill, including tens of thousands of responders, several thousand vessels, and the release of a large amount of dispersants.

A catastrophic spill has the potential to cause population level impacts to offshore biological resources. Multiple Federal and State-listed, threatened and endangered species could be impacted in the water column or at the sea surface. In addition, natural processes (e.g., flocculation) and human intervention (i.e., subsea dispersants) could expose benthic communities and archaeological sites to oil. Additionally, known and previously undiscovered archaeological sites and benthic habitats could be damaged by bottom-disturbing activities associated with the response effort, including anchoring of vessels. Pollutants in the spilled oil that are hazardous to response workers without protective equipment would be emitted into the air through evaporation and through in-situ or controlled burns of oil slicks.

Socioeconomic impacts would begin while the spill is still offshore. A large portion of the Gulf of Mexico EEZ and most of State waters could be closed to commercial and recreational fishing for several months, possibly causing the loss of revenue for an entire season or year. These closures may predominately affect minority or ethnic groups. Tourism may also be impacted due to either perceived damage to recreational resources that has not yet materialized or to general hesitation on the part of travelers to visit the overall region due to the spill. Suspension of some oil and gas activities would be possibly follow a catastrophic event, temporarily affecting jobs in the oil and gas industry.

7.3. SUMMARY OF IMPACTS FROM PHASE 3 (ONSHORE CONTACT)

The third phase of the catastrophic event analyzed is oiling of the shoreline. Exponential increase of the length of shoreline impacted is expected as the spill would continue over several months, which would likely overwhelm response efforts. Due to longer intervention times, a deepwater blowout and spill could impact over 1,000 miles of shoreline. While a catastrophic spill from a shallow-water blowout is expected to be a lower volume than a deepwater blowout, the site would generally be located closer to

shore, allowing less time for oil to be weathered, dispersed, and recovered. This could result in more concentrated and toxic oiling of several hundred miles of shoreline for more than 2 months.

The severity of oiling would vary between heavy, moderate, light, and occasional tarballs. However, due to the length of shoreline that could be potentially oiled and the sensitivity of the Gulf Coast, a catastrophic spill could cause extensive habitat degradation. Loss of vegetation could lead to erosion and permanent landloss. Though response efforts (including the use of skimmers and booms) would decrease the amount of oil contacting the coastline, significant amounts of oil would remain to impact coastal water quality. Gulf of Mexico water quality is already rated as fair to poor, according to USEPA. Depending on timing and location, a catastrophic spill has the potential to cause population-level impacts on biological resources. Dozens of Federal and State-listed, threatened and endangered species could be impacted. Impacts on air quality may have adverse effects on oil spill responders.

While cultural resources were recognized as significant early in the response and archaeologists are at present embedded in SCAT teams and consulting with cleanup crews, efforts to prevent coastal cultural resources from becoming contaminated by oil would likely be overwhelmed by the magnitude of shoreline impacted and/or in the event of a hurricane during the spill cleanup efforts. In addition to closures in Federal waters, portions to all of individual State waters would also be closed to commercial and recreational fishing. The economic impact of these closures would have a disproportional effect on minority and low-income groups, and shoreline impacts would generate additional subsistence-related effects. A catastrophic spill also has the potential to significantly impact the Gulf Coast recreation and tourism industries, particularly water-dependent and beach-dependent components of these industries. An influx of cleanup and relief workers would not fully offset economic impacts. The influx a large number of responders and the creation of staging areas due to a catastrophic spill would have temporary impacts (e.g., increased traffic congestion and some possible competing land use issues) on land use and infrastructure. In addition, there is a potential for delays in cargo handling and slow vessel traffic due to decontamination operations at various sites along the marine transportation system.

7.4. Summary of Impacts from Phase 4 (Long-Term Impacts)

Phase 4 focuses on the long-term impacts of a catastrophic oil spill. While impacts to air and water quality may be shorter term, a catastrophic spill can have impacts on Gulf of Mexico ecosystems long after the well is capped or killed and cleanup activities have concluded. In some cases, marine ecosystems may take decades to fully recover or may recover to alternative states.

Coastal and offshore habitats serve important ecological functions. Onshore, the loss of vegetation could lead to erosion and permanent landloss. Offshore, repopulation of benthic communities could take longer for areas affected by direct oil contact in higher concentrations. For birds, fish, marine mammals and sea turtles, damage of habitats, loss of reproductively capable adults as well as juveniles, and sublethal impacts from oil exposure can lead to impaired reproduction. This can potentially reduce population levels. For example, a catastrophic spill could decrease available habitat for associated organisms and indirectly affect the survival rate and recruitment for associated fish species. In the case of birds, long-term, sublethal, chronic effects may exceed immediate losses due to direct mortality (i.e., oiled birds) if such residual effects influence a significant proportion of the population or disproportionately impact an important population segment. A catastrophic spill could cause the destruction of the remaining habitat of certain onshore species, such as the diamondback terrapin or beach mice.

A catastrophic spill can also have long-term impacts on socioeconomic resources. Positive employment impacts related to response activities are likely to be shorter term than the negative impacts. Catastrophic spills have a huge regional economic impact (billions of dollars) as recently seen with the *Deepwater Horizon* incident. The longer-term implications for commercial and recreational fishing and tourism depend on the extent and perception of environmental damage. After the spill is stopped, the primary environmental justice concerns would be long-term health impacts of predominately minority workers and the disposal of oil-impacted solid waste in predominantly minority areas. Long-term impacts to land use and coastal infrastructure are not expected. Unlike biological or other socioeconomic resources that have the potential to recover, damage to archaeological resources from the spill or cleanup activities would be irreversible, leading to loss of important archaeological data needed for proper study and interpretation.

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9. REFERENCES

Adcroft, A., R. Hallberg, J.P. Dunne, B.L. Samuels, J.A. Galt, C.H. Barker, and B. Payton. 2010. Simulations of underwater plumes of dissolved oil in the Gulf of Mexico. Geophysical Research Letters. Vol. 37. 5 pp.

Aguilera, F., J. Méndez, E. Pásaro, and B. Laffon. 2010. Review on the effects of exposure to spilled oils on human health. Journal of Applied Toxicology, 30: 291–301. doi:10.1002/jat.1521

Alabama State Port Authority. 2010. Spill continues to impact Gulf Coastal States, Port of Mobile will remain open. Media Update, July 2, 2010. Internet website: http://www.asdd.com/pdf/ASPA_PortofMobile_OilSpillUpdate_07022010.pdf.

Albers, P.H. 1980. Transfer of crude oil from contaminated water to bird eggs. Environmental Research 22:307-314.

Albers, P.H. and G.H. Heinz. 1983. FLIT-MLO and No. 2 fuel oil: Effects of aerosol applications to mallard eggs on hatchability and behavior of ducklings. Environmental Research 30:381-388.

Alexander, S.K. and J.W. Webb. 1983. Effects of oil on growth and decomposition of *Spartina alterniflora*. In: Proceedings, 1983 Oil Spill Conference. February 28-March 3, 1983, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 529-532.

Alexander, S.K. and J.W. Webb. 1987. Relationship of *Spartina alterniflora* growth to sediment oil content following an oil spill. In: Proceedings, 1987 Oil Spill Conference. . .April 6-9, 1988, Baltimore, MD. Washington, DC: American Petroleum Institute. Pp. 445-450.

Alonso-Alvarez, C., I. Munilla, M. López-Alonso, and A. Veland. 2007. Sublethal toxicity of the Prestige oil spill on yellow-legged gulls. Environ. Int. 54:773-781.

Australian Maritime Safety Authority. 2010. Oil spill dispersants: Top 20 frequently asked questions (FAQs). Internet website: http://www.amsa.gov.au/Marine_Environment_Protection/National_plan/General_Information/Dispersants_Information/FAQ_Oil_Spills_Dispersants.asp. Accessed June 29, 2010.

Aversa, J. 2010. Oil spill's economic damage may not go beyond Gulf. Internet website: http://www.washingtonpost.com/wp-dyn/content/article/2010/06/28/AR2010062800624.html. Accessed June 30, 2010.

Baca, B., G.A. Ward, C.H. Lane, and P.A. Schuler. 2005. Net environmental benefit analysis (NEBA) of dispersed oil on nearshore tropical ecosystems derived from the 20 year "TROPICS" field study. In: Proceedings 2005 International Oil Spill Conference. May 15-19, 2005, Miami Beach, FL. Washington, DC: American Petroleum Institute.

Baird, P.H. 1990. Concentrations of seabirds at oil-drilling rigs. Condor 92:768-771.

Bak, R.P.M. and J.H.B.W. Elgershuizen. 1976. Patterns of oil-sediment rejection in corals. Marine Biology 37:105-113.

Bankston, Carl L. and M. Zhou. 1996. Go fish: The Louisiana Vietnamese and ethnicentrepreneurship in an extractive industry. National Journal of Sociology 10(1): 37-55.

Barras, J.A. 2006. Land area change in coastal Louisiana after the 2005 hurricanes: A series of three maps. U.S. Dept. of the Interior, Geological Survey. Open File Report 06-1274.

Barras, J.A., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. Historical and projected coastal Louisiana land changes: 1978-2050. U.S. Dept. of the Interior, Geological Survey. Open File Report 03-334.

Bartha, R. and R.M. Atlas. 1983. Transport and Transformations of Petroleum: Biological Processes. *In* D.F.Boesch and N.N. Rabalais (Eds). Long-term environmental effects of offshore oil and gas development. Taylor and Francis, Abingdon.

Beck, M.W., K.L. Heck, Jr., K.W. Able, D.L. Childers, D.B. Eggleston, B.M. Gillanders, B. Halpern, C.G. Hays, K. Hoshino, T.J. Minello, R.J. Orth, P.F. Sheridan, and M.P. Weinstein. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. BioScience 51(8):633-641.

Beck, W.W., W.L. Kruczynski, and P.F. Sheridan. 2006. Conclusion. In: Handley, D.A, D. Altsman, and R. DeMay, eds. 2006. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. Scientific Investigations Report 2006-5287. U.S. Environmental Protection Agency 855-R-04-003. Internet website: http://pubs.usgs.gov/sir/2006/5287/. Accessed October 28, 2010.

Bittner, J.E. 1996. Cultural resources and the Exxon-Valdez oil spill: An overview. Proceedings of the Exxon-Valdez Oil Spill Symposium. American Fisheries Society Symposium 18:814-818.

Boesch, D. F. and N.N. Rabalais, eds. 1987. Long-term environmental effects of offshore oil and gas development. London: Elsevier Applied Science Publishers. 696 pp.

Burdeau, C. 2010. Widespread oyster deaths found on Louisiana reefs. The Associated Press. July 17, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/07/widespread_oyster_deaths_found.html.

Burdeau C. and J. Collins. 2010. Marshes fouled by Gulf of Mexico oil spill show signs of regrowth. The Associated Press. August 12, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/08/marshes_fouled_by_gulf_of_mexi.html.

Burns, K.A. and A.H. Knap. 1989. The Bahía Las Minas oil spill: Hydrocarbon uptake by reef building corals. Marine Pollution Bulletin 20(8): 391-398.

Byrd, G.V., J.H. Reynolds, and P.L. Flint. 2009. Persistence rates and detection probabilities of bird carcasses on beaches of Unalaska Island, Alaska, following the wreck of the M/V Selendang Ayu. Marine Ornithology 37:197-204.

Caetano, M., M.J. Madureira, and C. Vale. 2003. Metal remobilization during resuspension of anoxic contaminated sediment: Short-term laboratory study. Water, Air, and Soil Pollution 143:23-40.

Cagle, F.R. 1952. A Louisiana terrapin population (*Malaclemys*). Copeia 1952:74-76.

Caldwell, A.B. 2003. Do terraces and coconut mats affect seeds and submerges aquatic vegetation at Sabine National Wildlife Refuge? Master's thesis, Louisiana State University, Baton Rouge, LA. 41 pp. Internet website: http://etd.lsu.edu/docs/available/etd-0625103-110131/unrestricted/Caldwell_thesis.pdf.

Canadian Center for Energy Information. 2010. What are oil sands and heavy oil? Internet website: http://www.centreforenergy.com/AboutEnergy/ONG/OilsandsHeavyOil/Overview.asp?page=1. Accessed on September 27, 2010.

Carls, M.G., S.D. Rice, and J. Hose. 1999. Sensitivity of fish embryos to weathered crude oil: Part 1. Low-level exposure during incubation causes malformations, genetic damage and mortality in larval Pacific herring (*Clupea pallashi*). Environmental Toxicology and Chemistry 18(3):481-493.

Carlson, P.R., Jr. and K. Madley. 2006. Statewide summary for Florida. In: Handley, D.A, D. Altsman, and R. DeMay, eds. 2006. Seagrass status and trends in the northern Gulf of Mexico: 1940-2002. Scientific Investigations Report 2006-5287. U.S. Environmental Protection Agency 855-R-04-003. Internet website: http://pubs.usgs.gov/sir/2006/5287/.

Castellanos, D.L. and L.P. Rozas. 2001. Nekton use of submerged aquatic vegetation, marsh, and shallow unvegetated bottom in the Atchafalaya River Delta, a Louisiana tidal freshwater ecosystem. Estuaries 24(2):184-197.

Centers for Disease Control and Prevention (CDC). 2010. NIOSH Report of BP illness and injury data (April 23 – June 6, 2010). Internet website: http://www.cdc.gov/niosh/topics/oilspillresponse/pdfs/NIOSHRept-BPInjuryandIllnessDataApril23-June6.pdf.

Clark Atlanta University. Environmental Justice Resource Center. 2010. BP waste oil spill waste disposal correction. Internet website: http://www.ejrc.cau.edu/GulfCorrection8-24-2010.html.

Cook, B.B. and A.H. Knap. 1983. The effects of crude oil and chemical dispersant on photosynthesis in the brain coral, *Diploria strigosa*. Marine Biology 78:21-27.

Conan, G. 1982. The long-term effects of the Amoco Cadiz oil spill. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 297(1087).

Council of Environmental Quality (CEQ). 2010. Report regarding the Minerals Management Service's National Environmental Policy Act policies, practices, and procedures as they relate to Outer Continental Shelf oil and gas exploration and development. 41 pp. Internet website: http://www.whitehouse.gov/sites/default/files/microsites/ceq/20100816-ceq-mms-ocs-nepa.pdf.

Darnell, R.M., R.E. Defenbaugh, and D. Moore. 1983. Atlas of biological resources of the continental shelf, northwestern Gulf of Mexico. U.S. Dept. of the Interior, Bureau of Land Management, New Orleans, LA. BLM Open File Report No. 82-04.

Davis, H.C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biological Bulletin, Marine Biological Laboratory 114(3):296-307.

Davis, B., D.S. Etkin, M. Landry, and K. Watts. 2004. Determination of oil persistence: A historical perspective. Proc. Fifth Biennial Freshwater Spills Symposium. Internet website: http://www.environmental-research.com/erc_papers/ERC_paper_19.pdf.

Deegan, L.A. 1989. Nekton, the free-swimming consumers. In: Day, J.W. Jr., C.A.S. Hall, W.M. Kemp, and A. Yanez-Arancibia, eds. Estuarine Ecology. New York, NY: Wiley and Sons Inc. 400 pp.

Delaune, R.D., W.H. Patrick, and R.J. Bureh. 1979. Effect of crude oil on a Louisiana *Spartina alterniflora* salt marsh. Environ. Poll. 20:21-31.

Dismukes, D. 2010a. Personal communication. Associate Director, LSU Center for Energy Studies, Baton Rouge, LA. September 1, 2010.

Dismukes, D. 2010b. Personal communication. Associate Director, LSU Center for Energy Studies, Baton Rouge, LA. August 30, 2010.

Dismukes, D.E., M. Barnett, D. Vitrano, and K. Strellec. 2007. Gulf of Mexico OCS oil and gas scenario examination: Onshore waste disposal. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 2007-051. 5 pp. Internet website: http://www.gomr.boemre.gov/PDFs/2007/2007-051.pdf.

Dodge, R.E., S.C. Wyers, A.H. Knap, H.R. Frith, T.D. Sleeter, and S.R. Smith. 1984. The effects of oil and oil dispersants on hermatypic coral skeletal growth (extension rate). Coral Reefs 3:191-198.

Ducklow, H.W. and R. Mitchell. 1979. Composition of mucus released by coral reef Coelenterates. Limnology and Oceanography 24(4):706-714.

Dunnet, G.M., D.J. Crisp, G. Conan, and W.R.P. Bourne. 1982. The long-term effects of oil pollution on marine populations, communities and ecosystems. Philosophical Transactions of the Royal Society of London. Series B, BiologicalSciences 297(1087):413-427. Internet website: http://www.jstor.org/stable/2396584. Accessed October 28, 2010.

Eccleston, C.H. 2008. NEPA and environmental planning: Tools, techniques, and approaches for practitioners. Boca Raton, FL: CRC Press. 447 pp.

Ejechi, B.O. 2003. Biodegradation of wood in crude oil-polluted soil. World Journal of Microbiology & Biotechnology 19(8):799-804. ISSN: 0959-3993.

Elgershuizen, J.H.B.W. and H.A.M. deKruijf. 1976. Toxicity of crude oils and a dispersant to the stony coral *Madracis mirabilis*. Marine Pollution Bulletin 7(2):22-25.

Energy Resources Co. Inc. (ERCO). 1982. IXTOC oil spill assessment: Executive summary. U.S. Dept. of the Interior, Bureau of Land Management, Contract No. AA851-CTO-71. Cambridge, MA. Internet website: http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3977.pdf. 39 pp.

Esler, D., J.A. Schmutz, R.L. Jarvis, and D.M. Mulcahy. 2000. Winter survival of adult female harlequin ducks in relation to history of contamination by the Exxon Valdez oil spill. Journal of Wildlife Management 64:839-847.

Fanning, K., K.L. Carder, and P.R. Betzer. 1982. Sediment resuspension by coastal waters: A potential mechanism for nutrient re-cycling on the ocean's margins. Deep-Sea Research 29:953-965.

Fingas, M., F. Ackerman, P. Lambert, K. Li, Z. Wang, J. Mullin, L. Hannon, D. Wang, A. Steenkammer, R. Hiltabrand, R. Turpin, and P. Campagna. 1995. The Newfoundland offshore burn experiment: Further results of emissions measurement. In: Proceedings of the Eighteenth Arctic and Marine Oilspill Program Technical Seminar, Volume 2, June 14-16, 1995, Edmonton, Alberta, Canada. Pp. 915-995.

Fischel, M., W. Grip, and I.A. Mendelssohn. 1989. Study to determine the recovery of a Louisiana marsh from an oil spill. In: Proceedings, 1989 Oil Spill Conference, February 13-16, 1989, San Antonio, TX. Washington, DC: American Petroleum Institute. Pp. 383-387.

Flint, P.L., A.C. Fowler, and R.F. Rockwell. 1999. Modeling losses of birds associated with the oil spill from the *M/V Citrus* off St. Paul Island, Alaska. Ecological Modeling 117:261-267.

Florida Fish and Wildlife Conservation Commission. 2010. Sea turtle nests to be moved Friday. June 22, 2 pp. Internet website: http://www.myfwc.com/NEWSROOM/10/statewide/News_10_X_OilSpill34.htm. Accessed September 29, 2010.

Flynn, D. 2010. NOAA closes Gulf spill area to fishing. Food Safety News. May 3, 2010. Internet website: http://www.foodsafetynews.com/2010/05/noaa-closes-spill-area-to-fishing/.

Ford, R.G., G.W. Page, and H.R. Carter. 1987. Estimating mortality of seabirds from oil spills. In: Proceedings of the 1987 Oil Spill Conference. Washington, DC: American Petroleum Institute. Pp. 747-751.

Fowler, A.C. and P.L. Flint. 1997. Persistence rates and detection probabilities of oiled King Eider carcasses on beaches of St. Paul Island, Alaska. Marine Pollution Bulletin 34:522-526.

Frithsen, J.B., R. Elmgren, and D.T. Rudnick. 1985. Responses of benthic meiofauna to long-term, low-level additions of No. 2 fuel oil. Marine Ecology Progress Series 23:1-14.

Fry, D.M., J. Swenson, L.A. Addiego, C.R. Grau, and A. Kang. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Archives of Environmental Contamination and Toxicology 15:453-463.

George-Ares, A. and J.R. Clark. 2000. Aquatic toxicology of two Corexit registered dispersants. Chemosphere 40(8):897-906.

Geraci, J.R. and D.J. St. Aubin, eds. 1990. Sea mammals and oil: Confronting the risks. San Diego: Academic Press.

Gesteria, J.L.G. and J.C. Dauvin. 2000. Amphipods are good bioindicators of the impact of oil spills on sift-bottom macrobenthic communities. Marine Pollution Bulletin 40(11):1017-1027.

Gittings, S.R., T.J. Bright, W.W. Schroeder, W.W. Sager, J.S. Laswell, and R. Rezak. 1992. Invertebrate assemblages and ecological controls on topographic features in the northeast Gulf of Mexico. Bulletin of Marine Science 50(3):435-455.

Golet, G.H., P.E. Seisner, A.D. McGuire, D.D. Roby, J.B. Fischer, K.J. Kuletz, D.B. Irons, T.A. Dean, S.C. Jewett, and S.H. Newman. 2003. Long-term direct and indirect effects of the *Exxon Valdez* oil spill on pigeon guillemots in Prince William Sound, Alaska. Marine Ecology Progress Series 241:287-304.

Guzmán, H.M. and I. Holst. 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea*. Marine Pollution Bulletin 26:276-282.

Guzman, H.M., J.B.C. Jackson, and E. Weil. 1991. Short-term ecological consequences of a major oil spill on Panamanian subtidal reef corals. Coral Reefs 10:1-12.

Haig, S.M., C.L. Ferland, F.J. Cuthbert, J. Dingledine, J.P. Goossen, A. Hecht, and N. McPhillips. 2005. A complete species census and evidence for regional declines in piping plovers. Journal of Wildlife Management 69:160-173.

Hamilton, P. 1990. Deep currents in the Gulf of Mexico. Journal of Physical Oceanography 20:1087-1104.

Hargreaves, S. 2010. Drilling ban: Jobs at stake. Internet website: http://money.cnn.com/2010/06/24/news/economy/drilling_jobs_at_stake/index.htm?postversion=2010062410. Accessed June 30, 2010.

Hazen, T.C., E.A. Dubinsky, T.Z. DeSantis, G.L. Andersen, Y.M. Picento, N. Singh, J.K. Jansson, A. Probst, S.E. Borglin, J.L. Fortney, W.T. Stringfellow, M. Bill, M.S. Conrad, L.M. Tom, K.L.

Chavarria, T.R. Alusi, R. Lamendella, D.C. Joyner, C. Spier, J. Baelum, M. Auer, M.L. Zelma, R. Chakraborty, E.L. Sonnenthal, P. D'haeseleer, H.N. Holman, S. Osman, Z. Lu, J.D. Van Nostrand, Y. Deng, J. Zhou, and O.U. Mason. 2010. Deep-Sea oil plume enriches indigenous oil-degrading bacteria. Science Express. August 24, 2010.

Hemmer, M.J., M.G. Barron, and R.M. Greene. 2010. Comparative toxicity of Louisiana sweet crude oil (LSC) and chemically dispersed LSC to two Gulf of Mexico aquatic test species. U.S. Environmental Protection Agency, Office of Research and Development. July 31, 2010.

Hemmerling, S.A. and C.E. Colten. 2003. Environmental justice considerations in Lafourche Parish, Louisiana: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-038. 348 pp.

Henry, J.M. and C.L. Bankston III. 1999. Louisiana Cajun ethnicity: Symbolic or structural? Sociological Spectrum: Mid-South Sociological Association, 1521-0707, 19(2):223-248.

Hernandez, D. 2010. Here's where BP is dumping its oil spill waste. ColorLines. August 4 2010. Internet website: http://colorlines.com/archives/2010/08/heres_where_bp_is_dumping_its_oil_spill_waste.html.

Hernandez, F.J., S. Powers, and W. Graham. 2010. Seasonal variability in ichthyoplankton abundance and seasonal composition in the northern Gulf of Mexico off Alabama. Fish Bull 108:193-207.

Hiett, R.L. and J.W. Milon. 2002. Economic impact of recreational fishing and diving associated with offshore oil and gas structures in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-010. 98 pp.

Hogan, J.L. 2003. Occurrence of the diamondback terrapin (*Malaclemys terrapin littoralis*) at South Deer Island in Galveston Bay, Texas, April 2001–May 2002. U.S. Dept. of the Interior, Geological Survey. USGS Open File Report 03-022. 30 pp.

Howell, K. 2010. Gulf spill roundup. *Greenwire*, July 2, 2010.

Institute of Medicine. 2010. Assessing the effects of the Gulf of Mexico oil spill on human health: A summary of the June 2010 workshop. Washington, DC: The National Academies Press. Internet website: http://www.iom.edu/Reports/2010/Assessing-the-Effects-of-the-Gulf-of-Mexico-Oil-Spill-on-Human-Health.aspx.

Inter-agency. 2010a. BP *Deepwater Horizon* oil budget: What happened to the oil? 5 pp. Internet website: http://www.restorethegulf.gov/sites/default/files/imported_pdfs/posted/2931/Oil_Budget_description_8_3_FINAL.844091.pdf.

Inter-agency. 2010b. Estimating the economic effects of the deepwater drilling moratorium on the Gulf Coast economy. 25 pp. Internet website: http://www.esa.doc.gov/drilling_moratorium.pdf.

Jackson, J.B.C., J.D. Cubit, B.D. Keller, V. Batista, K. Burns, H.M. Caffey, R.L. Caldwell, S.D. Garrity, C.D. Getter, C. Gonzalez, H.M. Guzman, K.W. Kaufmann, A.H. Knap, S.C. Levings, M.J. Marshall, R. Steger, R.C. Thompson, and E. Weil. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243:37-44.

Jernelöv, A. and O. Lindén. 1981. *Ixtoc* I: A case study of the world's largest oil. Ambio 10(6):299-306.

Jindal, Governor Bobby. 2010. Governor Jindal letter to President Obama and Secretary Salazar: Severe impacts of moratorium on deepwater drilling. Internet website: http://emergency.louisiana.gov/Releases/06032010-letter.html. Accessed June 30, 2010.

Johansen, O., H. Rye, and C. Cooper. 2001. DeepSpill JIP—field study of simulated oil and gas blowouts in deep water. In: Proceedings from the Fifth International Marine Environment Modeling Seminar, October 9-11, 2001, New Orleans, LA. 377 pp.

Joint Analysis Group (JAG). 2010. Review of R/V Brooks McCall data to examine subsurface oil. Internet website: http://www.noaa.gov/sciencemissions/PDFs/JAG_Report_1_BrooksMcCall_Final_June20.pdf. Accessed October 14, 2010.

Kaplan, M.F. and C. Whitman. 2008. Measuring the economic impact of tourism and recreation industries on Gulf Coast communities—relationship between OCS development and coastal resources. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. Prepared under MMS Contract No. 1435-01-99-CA-30951-85248 by Louisiana State University, Baton Rouge, LA.

Kennedy, C.J., N.J. Gassman, and P.J. Walsh. 1992. The fate of benzo[a]pyrene in the Scleractinian corals *Favia fragrum* and *Montastrea annularis*. Marine Biology 113:313-318.

Keithly, W and H. Diop. 2001. The Demand for Eastern Oysters, Crassostrea virginica, from the Gulf of Mexico in the Presence of *Vibrio vulnificus*. Marine Fisheries Review 63(1) 47-53.

Kingston, P.F., I.M.T. Dixon, S. Hamilton, and D.C. Moore. 1995. The impact of the Braer oil spill on the macrobenthic infauna of the sediments off the Shetland Islands. Marine Pollution Bulletin 30(7):445-459.

Kirkeleit J., T. Riise, M. Bråtveit and B.E. Moen. 2008. Increased risk of acute myelogenous leukemia and multiple myeloma in a historical cohort of upstream petroleum workers exposed to crude oil. Cancer Causes Control. 2008 Feb;19(1):13-23. Epub 2007 Sep 29. Internet website: http://www.ncbi.nlm.nih.gov/pubmed/17906934.

Kirsch, E.M. and J.G. Sidle. 1999. Status of the interior population of least tern. Journal of Wildlife Management 63:470-483.

Knap, A.H. 1987. Effects of chemically dispersed oil on the brain coral, *Diploria strigosa*. Marine Pollution Bulletin 18(3):119-122.

Knap, A.H., J.E. Solbakken, R.E. Godge, T.D. Sleeter, S.C. Wyers, and K.H. Palmork. 1982. Accumulation and elimination of (9-14C) phenanthrene in the reef-building coral (*Diploria strigosa*). Bulletin of Environmental Contamination and Toxicology 28:281-284.

Knap, A.H., S.C. Wyers, R.E. Dodge, T.D. Sleeter, H.R. Frith, S.R. Smith, and C.B. Cook. 1985. The effects of chemically and physically dispersed oil on the brain coral, *Diploria strigosa* (Dana)—a summary review. In: Proceedings 1985 Oil Spill Conference, Los Angeles, CA. (USCG/API/EPA) API Publ. No. 4385:547-551.

Knowland Group, The. 2010. Survey data. Internet website: www.hotelnewsresource.com/article46295.html.

Kushmaro, A., G. Henning, D.K. Hofmann, and Y. Benayahu. 1997. Metamorphosis of *Heteroxenia fuscescens* Plaunlae (Cnidaria: Octocorallia) is inhibited by crude oil: A novel short term toxicity bioassay. Marine Environmental Research 43(4):295-302.

Lange, R. 1985. A 100 ton experimental oil spill at Halten Bank, off Norway. In: Proceedings, 1985 Oil Spill Conference. February 25-28, 1985, Los Angeles, CA. Washington, DC: American Petroleum Institute.

LeDee, O.E., F.J. Cuthbert, and P.V. Bolstad. 2008. A remote sensing analysis of coastal habitat composition for a threatened shorebird, the piping plover (*Charadrius melodus*). Journal of Coastal Research 24:719-726.

Leighton, F.A. 1993. The toxicity of petroleum oils to birds. Environ. Rev. 1:92-103.

Lewis, J.B. 1971. Effects of crude oil and oil spill dispersant on coral reefs. Marine Pollution Bulletin 2:59-62.

Lin, Q., I.A. Mendelssohn, M.T. Suidan, K. Lee, and A.D. Venosa. 2002. The dose-response relationship between No. 2 fuel oil and the growth of the salt marsh grass, Spartina alterniflora. Marine Pollution Bulletin 44. 897-902.

Lin Q. and Mendlessohn, Irve. 2009. Potential of restoration and phytoremediation with Juncus roemerianus for diesel-contaminated coastal wetlands.Ecological Engineering 8 January 2009, Pages 85-91. Internet site last visited December 16, 2010 .http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VFB-4V2J6J8-4&_user=10&_coverDate=01%2F08%2F2009&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1619317074&_rerunOrigin=scholar.google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=e4e701499ce803ec8e0d60bf57c2d99c&searchtype=a

Louisiana, The State of. 2010a. Report on oil sightings throughout coastal Louisiana. Press Release. September 17, 2010. Internet website: http://emergency.louisiana.gov/Releases/91710Sightings.html.

Louisiana, The State of. 2010b. Report on oil sightings throughout coastal Louisiana. Press Release. September 16, 2010. Internet website: http://emergency.louisiana.gov/Releases/091610Sightings.html.

Louisiana, The State of. 2010c. Report on oil sightings throughout coastal Louisiana. Press Release. September 14, 2010. Internet website: http://emergency.louisiana.gov/Releases/91410Sightings.html.

Louisiana, The State of. 2010d. Report on oil sightings throughout coastal Louisiana. Press Release. September 13, 2010. Internet website: http://emergency.louisiana.gov/Releases/91310Sightings.html.

Louisiana, The State of. 2010e. Report on coastal skimming activities in Louisiana. Press Release. September 17, 2010. Internet website: http://emergency.louisiana.gov/Releases/91710Skimming.html.

Louisiana Mid-Continent Oil and Gas Association (LMOGA). 2010. Impact of President Obama's order halting work on 33 exploratory wells in the deepwater Gulf of Mexico. Internet website: http://www.lmoga.com/Economic%20Impacts%20of%20Gulf%20Moratorium.pdf. Accessed July 7, 2010.

Louisiana Universities Marine Consortium (LUMCON). 2010. 2010 Dead zone—one of the largest ever. LUMCON News. Internet website: http://www.lumcon.edu/Information/news/default.asp?XMLFilename=201008021451.xml. Accessed August 10, 2010.

Lytle, J.S. 1975. Fate and effects of crude oil on an estuarine pond. In: Proceedings, Conference on Prevention and Control of Oil Pollution, San Francisco, CA. Pp. 595-600.

Market Dynamics Research Group. 2010. Importance of leisure travel attributes and perceptions of Louisiana. Internet website: http://www.louisianatravel.com/.

McAuliffe, C.D., A.E. Smalley, R.D. Groover, W.M. Welsh, W.S. Pickle, and G.E. Jones. 1975. Chevron Main Pass Block 41 oil spill: Chemical and biological investigation. In: Proceedings, 1975 Conference on Prevention and Control of Oil Pollution, March 25-27, 1975, San Francisco, CA. Washington, DC: American Petroleum Institute.

McAuliffe, C.D., B.L. Steelman, W.R. Leek, D.F. Fitzgerald, J.P. Ray, and C.D. Barker. 1981. The 1979 southern California dispersant treated research oil spills. In: Proceedings 1981 Oil Spill Conference. March 2-5, 1981, Atlanta, GA. Washington, DC: American Petroleum Institute. Pp. 269-282.

McGimsey, C. 2010. Personal communication. Discussion with the State Archaeologist, Louisiana Division of Archaeology, Department of Culture, Recreation, and Tourism with regard to effects of the oil spill on cultural resources.

Mechalas, B.J. 1974. Pathways and environmental requirements for biogenic gas production in the ocean. In: Kaplan, I.R., ed. Natural Gases in Marine Sediments. Marine Science, Volume 3. New York, NY: Plenum Press.

Michel, J. 1992. Chapter 2. Oil behavior and toxicity. In: Introduction to coastal habitats and biological resources for spill response. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. NOAA Report No. HMRAD 92-4. Internet website: http://response.restoration.noaa.gov/type_subtopic_entry.php?RECORD_KEY%28entry_subtopic_type%29=entry_id,subtopic_id,type_id&entry_id(entry_subtopic_type)=275&subtopic_id(entry_subtopic_type)=8&type_id(entry_subtopic_type)=2.

Mitchell, R. and I. Chet. 1975. Bacterial attack of corals in polluted seawater. Microbial Ecology 2:227-233.

Mock, Brentin. (May 2010). “Boats moored by the BP oil spill, a long-threatened community of black fishers fears for its future.” The Lens: Investigating New Orleans and the Gulf Coast. http://www.projectnola.com/component/content/article/86-the-lens/90049-boats-moored-by-the-bp-oil-spill-a-long-threatened-community-of-black-fishers-fears-for-its-future

Moore, S.F. and R.L. Dwyer. 1974. Effects of oil on marine organisms: A critical assessment of published data. Water Research 8:819-827.

Morton R.A., T.L. Miller, and L.J. Moore. 2004. Historical shoreline changes along the US Gulf of Mexico: A summary of recent shoreline. U.S. Dept. of the Interior, Geological Survey. Open File Report 2004-1089. Internet website: http://pubs.usgs.gov/of/2004/1089/references.html.

Murray, S.P. 1998. An observational study of the Mississippi/Atchafalaya coastal plume: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 98-0040. 513 pp.

National Association for the Advancement of Colored People (NAACP). 2010. NAACP blasts BP for oil spill response. July 10, 2010. Internet website: http://www.thegrio.com/opinion/naacp-what-we-want-to-see-with-bp.php.

National Research Council (NRC). 2003. Oil in the sea III: Inputs, fates, and effects (Committee on Oil in the Sea: J.N. Coleman, J. Baker, C. Cooper, M. Fingas, G. Hunt, K. Kvenvolden, J. McDowell, J. Michel, K. Michel, J. Phinney, N. Rabalais, L. Roesner, and R.B. Spies). Washington, DC: National Academy Press. 265 pp.

National Research Council (NRC). 2005. Oil spill dispersants: Efficacy and effects. Washington, DC: National Academy Press. 377 pp.

NaturalGas.org. 2010. Internet website: http://www.naturalgas.org/overview/background.asp. Accessed August 25, 2010.

Neff, J.M., S. McKelvie, and R.C. Ayers, Jr. 2000. Environmental impacts of synthetic based drilling fluids. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-064. 118 pp.

Newton, I. 1998. Population limitation in birds. San Diego, CA: Academic Press.

Nodar, J. 2010. Gulf tanker decontaminated before entering Mississippi. The Journal of Commerce Online. May 26, 2010. Internet website: http://www.joc.com/maritime/tanker-requires-cleaning-entering-mississippi-river.

Nolan, B. and A. Good. 2010. Moratorium in wake of Gulf oil spill idles much more than rigs, workers. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/07/moratorium_in_wake_of_gulf_oil.html. Accessed July 6, 2010.

Odess, D. 2010. Personal communication. Telecon regarding Section 106 in relation to response to the oil spill.

Odess, D. 2011. Personal communication. Trustees Meeting January 12, 2011, New Orleans, LA.

Office of the Governor, State of Florida. 2010. Gulf oil spill situation update. Florida Releases. July 18, 2010. Internet website: http://www.thegovmonitor.com/world_news/united_states/florida-releases-july-18-2010-gulf-oil-spill-situation-update-35721.html.

Oxford Economics. 2010. Potential impact of the Gulf oil spill on tourism. Internet website: www.ustravel.org/sites/default/files/page/2009/11/Gulf_Oil_Spill_Analysis_Oxford_Economics_710.pdf.

Patin, S. 1999. Gas impacts on fish and other marine organisms. In: Environmental impact of the offshore oil and gas industry. New York, NY: EcoMonitor Publishing. 425 pp.

PCCI Marine and Environmental Engineering (PCCI). 1999. Oil spill containment, remote sensing and tracking for deepwater blowouts: Status of existing and emerging technologies, final report. Prepared for U.S. Dept. of the Interior, Minerals Management Service, Alexandria, VA. Purchase Order Number 1435-01-98-PO-15135. Internet website: http://www.boemre.gov/tarprojects/311/311AA.pdf.

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.E. Ballachey, and. D.B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302:2082-2086.

Piatt, J.F. and R.G. Ford. 1996, How many seabirds were killed by the *Exxon Valdez* oil spill? In: S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright, eds. Proceedings of the *Exxon Valdez* oil spill symposium. Am. Fisheries Soc. Symposium 18, Bethesda, MD. Pp. 712-719.

Piatt, J.F., H.R. Carter, and D.N. Nettleship. 1990. Effects of oil pollution on marine bird populations. In: White, J., ed. The effects of oil on wildlife: research, rehabilitation and general concerns. Hanover, PA: Sheridan Press.

Plotkin, P.T., ed. 1995. National Marine Fisheries Service and U.S. Fish and Wildlife Service Status reviews for sea turtles listed under the Endangered Species Act of 1973. U.S. Dept. of Commerce, National Marine Fisheries Service, Silver Spring, MD.

Powell, J.A. and G.B. Rathbun. 1984. Distribution and abundance of manatees along the northern coast of the Gulf of Mexico. Northeast Gulf Sci. 7:1-28.

Pritchard, E.S., ed. 2009. Fisheries of the United States: 2008. U.S. Dept. of Commerce, National Marine Fisheries Service, Office of Science and Technology, Fisheries Statistics Division, Silver Spring, MD.

Ragen, T.J. 2010. Testimony of Timothy J. Ragen, Executive Director, U.S. Marine Mammal Commission, before the House Subcommittee on Insular Affairs, Oceans, and Wildlife, regarding the *Deepwater Horizon* oil spill and its effects on marine mammals. June 10, 2010. 8 pp. Internet website: http://www.mmc.gov/testimony/pdf/testimony_061010.pdf. Accessed September 29, 2010.

Rathbun, G.B., J.P. Reid, and G. Carowan. 1990. Distribution and movement patterns of manatees (*Trichechus manatus*) in northwestern peninsular Florida. FL Mar. Res. Publ. No. 48. 33 pp.

Ravitz, J. 2010. Vietnamese fishermen in Gulf fight to not get lost in translation. CNN. June 25, 2010. Internet website: http://www.flutrackers.com/forum/showthread.php?t=148708.

Regg, J. 2000. Deepwater development: A reference document for the deepwater environmental assessment, Gulf of Mexico OCS (1997 through 2000). U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Report MMS 99-0066. Internet website: http://www.gomr.boemre.gov/PDFs/2000/2000-015.pdf.

Restrepo, C.E., F.C. Lamphear, C.A. Gunn. R.B. Ditton, J.P. Nichols, and L.S. Restrepo. 1982. IXTOC I oil spill economic impact study, executive summary. Report prepared by Restrepo and Associates for the U.S. Dept. of the Interior, Bureau of Land Management, New Orleans OCS Office, New Orleans, LA.

Rhodes, D.C. and J.D. Germano. 1982. Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote ecological monitoring of the seafloor (Remots™ System). Marine Ecology Progress Series 8:115-128.

Rice, S.A. and C.L. Hunter. 1992. Effects of suspended sediment and burial on Scleractinian corals from west central Florida patch reefs. Bulletin of Marine Science 51(3):429-442.

Rogers, C.S. 1990. Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series 62:185-202.

Rogers, C.S. and V.H. Garrison. 2001. Ten years after the crime: Lasting effects of damage from a cruise ship anchor on a coral reef in St. John, U.S. Virgin Islands. Bulletin of Marine Science 69(2):793-803.

Russell, R.W. 2005. Interactions between migrating birds and offshore oil and gas platforms in the northern Gulf of Mexico: Final Report. U.S. Dept. of the Interior, Minerals Management Service, U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.

Sanders, H.L., J.F. Grassle, G.R. Hamson, L.S. Morse, S. Garner-Price, and C.C. Jones. 1980. Anatomy of an oil spill: Long-term effects from the grounding of the barge *Florida* off West Falmouth, Massachusetts. Journal of Marine Research 38:265-380.

Savitz, D.A. and L.S. Engel. 2010. Lessons for study of the health effects of oil spills. Annals of Internal Medicine. August 23, 2010. Internet website: http://www.annals.org/content/early/2010/08/23/0003-4819-153-8-201010190-00276.full.

Sathiakumar, Nalini. 2010. "Short-term Physical Effects Oil Spills." Presentation, School of Public Health, University of Alabama at Birmingham. Internet website: http://www.iom.edu/~/media/Files/Activity%20Files/PublicHealth/OilSpillHealth/NaliniSathiakumar-6-22-1110am.pdf

Schenkman, L. 2010. Gulf cruise raises questions on methane, but much data still to analyze. *Science Insider*. June 23, 2010. Internet website: http://news.sciencemag.org/scienceinsider/2010/06/gulf-cruise-raises-questions-on-.html.

Schiro, A.J., D. Fertl, L.P. May, G.T. Regan, and A. Amos. 1998. West Indian manatee (*Trichechus manatus*) occurrence in U.S. waters west of Florida. Presentation, World Marine Mammal Conference, 20-24 January, Monaco.

Schleifstein, M. 2010. Environmental justice concerns arising from Gulf of Mexico oil spill aired. Times-Picayune. June 15, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/06/environmental_justice_concerns.html.

Scholz, D.K., J.H. Kucklick, R.G. Pond, A.H. Walker, A. Bostrom, and P. Fischbeck. 1999. Fate of spilled oil in marine waters: Where does it go? What does it do? How do dispersants affect it? An information booklet for decision-makers. American Petroleum Institute Publication Number 4691.

ScienceDaily. 2010. Spawning habitat of bluefin tuna in Gulf of Mexico: Critical area intersects *Deepwater Horizon* oil spill. May 31, 2010. Internet website: http://www.sciencedaily.com/releases/2010/05/100528210726.htm.

Sheridan, P. and T.J. Minello. 2003. Nekton use of different habitat types in seagrass beds of lower Laguna Madre, Texas. Bulletin of Marine Science 72(1):37-61.

Shigenaka, G. 2001. Toxicity of oil to reef-building corals: A spill response perspective. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, WA. NOAA Technical Memorandum NOS OR&R 8. 95 pp. Internet website http://response.restoration.noaa.gov/book_shelf/1_coral_tox.pdf.

Short, F.T. and R.G. Coles (eds.). 2001. Global Seagrass Research Methods. Elsevier Science B.V. Amsterdam, The Netherlands. 473 pp.

Short, F.T. R.G. Coles, and C. Pergent-Martini. 2001. Global seagrass distribution. In: Short, F.T. and R.G. Coles, eds. 2001. Global seagrass research methods. Amsterdam, The Netherlands: Elsevier Science B.V. Pp 5-6, 20.

St. Aubin, D.J. and V. Lounsbury. 1990. Oil effects on manatees: Evaluating the risks. In: Geraci, J.R. and D.J. St. Aubin, eds. Sea mammals and oil: Confronting the risk. San Diego, CA: Academic Press. Pp. 241-251.

Szell, C.C. and M.S. Woodrey. 2003. Reproductive ecology of the least tern along the lower Mississippi River. Waterbirds 26:35-43.

Tasker, M.L., P. Hope-Jones, B.F. Blake, T.J. Dixon, and A.W. Wallis. 1986. Seabirds associated with oil production platforms in the North Sea. Ringing and Migration 7:7-14.

Taylor, H.A., M.A. Rasheed, and R. Thomas. 2006. Port Curtis post oil spill seagrass assessment, Gladstone-2006. DPI&F Information Series QI06046 (DPI&F, Cairns). 19 pp. Internet website: http://www.seagrasswatch.org/Info_centre/Publications/pdf/meg/GladstonePostOilSpillReport2006_Final.pdf.

Thompson, J.H. 1980. Effects of drilling mud on seven species of reef-building coral as measured in field and laboratory. Report to the U.S. Dept. of Interior, Geological Survey by Texas A&M University, Department of Oceanography, College Station, TX.

Tokotch, B. 2010. Oil and coral fact sheet. 3 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/Oil-CoralOnePage.pdf.

Tolbert, C.M. 1995. Oil and gas development and coastal income inequality: A comparative analysis. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 94-0052. 75 pp.

Trapido, Edward J., Sc.D., F.A.C.E. "Health and the *Deepwater Horizon* Gulf Oil Spill." (October 5-6, 2010). JSOST *Deepwater Horizon* Oil Spill Principal Investigator (PI) Conference, St. Petersburg, FL.

Unified Incident Command. 2010a. Vessel decontamination stations available around Louisiana. *Deepwater Horizon* Incident Joint Information Center. June 20, 2010. Internet website: http://www.deepwaterhorizonresponse.com/go/doc/2931/679467/.

Unified Incident Command. 2010b. Ask a responder: Q & A with Coast Guard Task Force leader for commercial vessel decontamination. September 29, 2010. Internet website: http://www.deepwaterhorizonresponse.com/go/doc/2931/828195/.

Unified Incident Command. 2010c. Media availability: Media invited to observe commercial-vessel decontamination operations. June 23, 2010. Internet website: http://www.deepwaterhorizonresponse.com/go/doc/2931/687191/.

Unified Incident Command. 2010d. Fish and Wildlife report, consolidated Fish and Wildlife collection report. Internet website: http://www.deepwaterhorizonresponse.com/go/doctype/2931/55963/&offset=0. Accessed September 29, 2010.

Unified Incident Command. 2010e. Unified Area Command continues to build a sea turtle observer program for on-water oil clean-up. *Deepwater Horizon* Incident Joint Information Center. July 2, 2010. Internet website: http://www.deepwaterhorizonresponse.com/go/doc/2931/734531/.

Unified Incident Command. 2010f. Unified Area Command daily report, August 25, 2010.

U.S. Department of Labor. Occupational Safety & Health Administration. 2010. "On-Shore & Off-Shore PPE Matrix for Gulf Operations." http://www.osha.gov/oilspills/gulfoperations-ppe-matrix.pdf

U.S. Department of Labor. Occupational Safety & Health Administration. 2010. Occupational Safety & Health Administration. "Keeping Workers Safe During Oil Spill Response and Cleanup Operations: Gulf Oil Response and Heat." http://www.osha.gov/oilspills/heatstress.html

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010a. NOAA assists with multi-agency effort to decontaminate ships passing through oil spill. May 28, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100528_ships.html.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA), 2010b. Administration's Joint Analysis Group releases first scientific report on subsea monitoring data from Gulf spill. Internet website: http://www.noaanews.noaa.gov/stories2010/20100623_brooks.html. Updated June 23, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010c. Second Federal analysis gives further clues about location and movement of subsurface oil. July 23, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100722_jag.html.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010d. No dead zones observed or expected as part of BP *Deepwater Horizon* oil spill. September 7, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100907_jag3.html.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010e. Using booms in response to oil spills. 4 pp. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/NOAA_boom_fact_sheet.pdf. Accessed September 29, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010f. What is an ecosystem? Internet website: http://ecosystems.noaa.gov/what_eco.htm. Accessed October 1, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). 2010g. NOAA closes commercial and recreational fishing in oil-affected portion of Gulf of Mexico. May 2, 2010. Internet website: http://www.noaanews.noaa.gov/stories2010/20100502_fisheries.html.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). Hazardous Materials Response and Assessment Division. 1992. Oil spill case histories, 1967-1991: Summaries of significant U.S. and international spills. HMRAD 92-11 to USCG Research and Development Center, Seattle, WA.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). National Marine Fisheries Service (NMFS). 2010a. Sea turtles, dolphins, and whales and the Gulf of Mexico oil spill. Internet website: http://www.nmfs.noaa.gov/pr/health/oilspill.htm. Accessed September 29, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). National Marine Fisheries Service (NMFS). 2010b. Fisheries economics of the United States, 2008. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-109, 177 pp. Internet website: http://www.st.nmfs.noaa.gov/st5/publication/index.html.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). National Marine Fisheries Service (NMFS). 2010c Annual commercial landings by group. 2 pp. Internet website: http://www.st.nmfs.noaa.gov/st1/commercial/landings/gc_runc.html. Accessed July 10, 2010

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). National Marine Fisheries Service (NMFS). 2010d. Impacts of oil on marine mammals and sea turtles. 2 pp. Internet website: http://www.nmfs.noaa.gov/pr/pdfs/health/oil_impacts.pdf.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). National Ocean Service (NOS). 2008. Gulf of Mexico at a glance. Washington, DC: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration.

U.S. Department of Commerce. National Oceanic Atmospheric Administration (NOAA). National Weather Service. 2010a. Tropical cyclone climatology. Internet website: http://www.nhc.noaa.gov/pastprofile.shtml. Updated July 14, 2010.

U.S. Department of Commerce. National Oceanic Atmospheric Administration (NOAA). National Weather Service. 2010b. NOAA's oil spill response: Hurricanes and the oil spill. Internet website: http://www.nhc.noaa.gov/pdf/hurricanes_oil_factsheet.pdf. Accessed May 27, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). NOAA Fisheries Service. 2010a. Information about the Federal fishing closure in oil-affected portions of the Gulf of Mexico. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, NOAA Fisheries Service, Southeast Regional Office, Saint Petersburg, FL. Southeast Fishery Bulletin, July 12, 2010. Internet website: http://sero.nmfs.noaa.gov/sf/deepwater_horizon/FB_Closure%20info_Eng.pdf

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). NOAA Fisheries Service. 2010b. *Deepwater Horizon*/BP oil spill: Size and percent coverage of fishing area closures due to BP oil spill. U.S. Dept. of Commerce, National Oceanic and Atmospheric

Administration, NOAA Fisheries Service, Southeast Regional Office, Saint Petersburg, FL. Internet website: http://sero.nmfs.noaa.gov/ClosureSizeandPercentCoverage.htm. Updated September 21, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). Office of Response and Restoration. 2010a. IXTOC I. Internet website: http://www.incidentnews.gov/incident/6250. Accessed on September 23, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). Office of Response and Restoration. 2010b. Chevron Main Pass Block 41. Internet website: http://www.incidentnews.gov/incident/6209. Accessed on September 23, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). Office of Response and Restoration. 2010c. Shell Platform 26. Internet website: http://www.incidentnews.gov/incident/6211. Accessed on September 23, 2010.

U.S. Department of Commerce. National Oceanic and Atmospheric Administration (NOAA). Office of Response and Restoration. 2010d. Shoreline threat update: Southern Florida, Florida Keys and East Coast *Deepwater Horizon*/BP oil spill, July 30, 2010. Internet website: http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY%28entry_subtopic_topic%29=entry_id,subtopic_id,topic_id&entry_id(entry_subtopic_topic)=815&subtopic_id(entry_subtopic_topic)=2&topic_id(entry_subtopic_topic)=1#evolution.

U.S. Department of Labor. 2010a. Quarterly census of employment and wages. Internet website: http://data.bls.gov:8080/PDQ/outside.jsp?survey=en.

U.S. Department of Labor. 2010b. QCEW fact sheet. June 2010. Internet website: http://www.bls.gov/cew/gulf_coast_leisure_hospitality.htm.

U.S. Department of Labor. Bureau of Labor Statistics (BLS). 2010. Fact sheet: Employment in the oil and gas well drilling industry. Internet website: http://www.bls.gov/cew/oil_gas_drilling.htm. Accessed July 1, 2010.

U.S. Department of Labor. Occupational Safety and Health Administration (OSHA). 2010a. Internet website: http://www.osha.gov/oilspills/index_sampling.html. Accessed on September 22, 2010.

U.S. Department of Labor. Occupational Safety and Health Administration (OSHA). 2010b. Direct reading results by site. Internet website: http://www.osha.gov/oilspills/oil_directreading_bysite.html. Updated August 4, 2010.

U.S. Department of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). 2010a. Spills ≥ 50 barrels (2,100 gallons)—1967. Internet website: http://www.boemre.gov/incidents/SigPoll67.htm. Updated September 17, 2010.

U.S. Department of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). 2010b. Gulf of Mexico Region, Spills ≥ 50 barrels (2,100 gallons)—1970. Internet website: http://www.boemre.gov/incidents/SigPoll70.htm.

U.S. Department of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). 2010c. Technical Information Management System (TIMS). Accessed September 13, 2010.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2004. Effects of oil spills on wildlife and habitat. December 2004. Internet website: http://alaska.fws.gov/media/unalaska/Oil%20Spill%20Fact%20Sheet.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2007. Alabama beach mouse—revision of critical habitat. January 2007. Daphne Ecological Services Field Office. Internet website: http://www.fws.gov/daphne/abm/pdf/ABM-FactSheet-finalCH-1-30-07.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2009. Stock assessment report for the West Indian manatee Florida stock. U.S. Dept. of the Interior, Fish and Wildlife Service, Jacksonville, FL. December 20, 2009. Internet website: http://www.fws.gov/northflorida/Manatee/SARS/20091230_rpt_Final_Florida_Manatee_SAR.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010a. Wildlife threatened on the Gulf Coast. June 2010. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/NewWildlifeOfGulf.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010b. Federally listed wildlife and plants threatened by Gulf oil spill. June 2010. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/FedListedBirdsGulf.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010c. Beach-nesting birds of the Gulf. May 2010. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/DHBirdsOfTheGulf.pdf

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010d. Bird impact data from DOI-ERDC database download 12 Oct. 2010. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/Bird%20Data%20Species%20Spreadsheet%2010122010.pdf.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010e. State and Federal wildlife agencies, other partners, move to safeguard sea turtle nests; FedEx providing transportation to Florida's Space Coast. News Release, July 9, 2010. Internet website: http://www.fws.gov/southeast/news/2010/r10-048.html.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010f. Species report. Internet website: http://ecos.fws.gov/tess_public/SpeciesReport.do. Accessed August 30, 2010.

U.S. Department of the Interior. Fish and Wildlife Service (FWS). 2010g. Effects of oil on wildlife and habitat. Fact Sheet, June 2010. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/DHJICFWSOilImpactsWildlifeFactSheet.pdf.

U.S. Department of the Interior. Minerals Management Service. 2000. Gulf of Mexico Deepwater Operations and Activities: Environmental Assessment. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans. OCS EIS/EA MMS 2000-001. Internet website: http://www.gomr.boemre.gov/PDFs/2000/2000-001.pdf.

U.S. Department of the Interior. Minerals Management Service. 2007. Gulf of Mexico OCS oil and gas lease sales: 2007-2012; Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222—final environmental impact statement. 2 vols. U.S. Dept. the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2007-018.

U.S. Department of the Interior. Minerals Management Service. 2008. Gulf of Mexico OCS oil and gas lease sales: 2009-2012; Central Planning Area Sales 208, 213, 216, and 222; Western Planning Area Sales 210, 215, and 218—final supplemental environmental impact statement. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS EIS/EA MMS 2008-041. Internet website http://www.gomr.mms.gov/PDFs/2008/2008-041.pdf.

U.S. Department of the Interior. Minerals Management Service. 2010. Preliminary revised program Outer Continental Shelf Oil and Gas Leasing Program, 2007-2012. Internet website: http://www.boemre.gov/5-year/PDFs/PRP2007-2012.pdf.

U.S. Department of the Interior. National Park Service (NPS). 2010. Managing sea turtles during the oil spill response. 2 pp. Internet website: http://www.deepwaterhorizonresponse.com/posted/2931/Managing_Sea_Turtles_During_the_Oil_Spill_Response.786623.pdf.

U.S. Department of Transportation (USDOT). 2010. Gulf Coast ports surrounding the deepwater horizon oil spill. Fact Sheet, June 2010. U.S. Dept. of Transportation, Research and Innovative Technology Administration. Internet website: http://www.bts.gov/publications/bts_fact_sheets/2010_001/pdf/entire.pdf.

U.S. Department of Transportation. Coast Guard (USCG). 2010. Dispersants/on-water oil removal capacity (CAPS). Internet website: https://homeport.uscg.mil/mycg/portal/ep/contentView.do?contentTypeId=2&channelId=-30095&contentId=125795&programId=114824&programPage=%2Fep%2Fprogram%2Feditorial.jsp&pageTypeId=13489. Updated April 26, 2010.

U.S. Environmental Protection Agency (USEPA). 2008. Coastal condition report III. U.S. Environmental Protection Agency, Office of Research and Development/Office of Water, Washington, DC. EPA/842-R-08-002. Internet website: http://water.epa.gov/type/oceb/assessmonitor/downloads.cfm.

U.S. Environmental Protection Agency (USEPA). 2010a. Questions and answers about the BP oil spill in the Gulf Coast. Internet website: http://www.epa.gov/BPSpill/qanda.html#waste19. Accessed August 31, 2010.

U.S. Environmental Protection Agency (USEPA). 2010b. Odors from the BP oil spill. Internet website: http://www.epa.gov/BPSpill/odor.html. Accessed October 1, 2010.

U.S. Environmental Protection Agency (USEPA). 2010c. BP's analysis of subsurface dispersant use. Internet website: http://www.epa.gov/bpspill/dispersants-bp.html.

U.S. Environmental Protection Agency (USEPA). 2010d. Recovered oil, contaminated materials and liquid and solid wastes management directive, Louisiana, June 29, 2010. Internet website: http://www.epa.gov/bpspill/waste/wastemanagementdirective_la.pdf.

U.S. Environmental Protection Agency (USEPA). 2010e. Recovered oil, contaminated materials and liquid and solid wastes management directive, Mississippi, Alabama, Florida, June 29, 2010. Internet website: http://www.epa.gov/bpspill/waste/wastemanagementdirective_msalfl.pdf.

U.S. Environmental Protection Agency (USEPA). Office of Research and Development. 2010a. Internet website: Comparative toxicity of Louisiana sweet crude oil (LSC) and chemically dispersed LSC to two Gulf of Mexico aquatic test species.13 pp.

U.S. Environmental Protection Agency (USEPA). Office of Research and Development. 2010b. Analysis of eight oil spill dispersants using *in vitro* tests for endrocrine and other biological activity. 47 pp. Appendices 61 pp.

U.S. Travel Association. 2010. The power of travel. Internet website: http://www.poweroftravel.org/statistics.

Vandermeulen, J.H. 1982. Some conclusions regarding long-term biological effects of some major oil spills. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. Vol. 297. No. 1087.

Velando, A., I. Munilla, M. Lopez-Alonso, J. Freire, and C. Perez. 2010. EROD activity and stable isotopes in seabirds to disentangle marine food web contamination after the Prestige oil spill. Environmental Pollution 158(2010):1275-1280. Internet website: http://webs.uvigo.es/cristobal/papers/8.EROD%20activity%20and%20stable%20isotopes%20in%20seabirds%20to%20disentangle%20marine%20food%20web%20contamination%20after%20the%20Prestige%20oil%20spill.pdf. Accessed October 28, 2010.

Ward, G.A., B. Baca, W. Cyriacks, R.E. Dodge, and A. Knap. 2003. Continuing long-term studies of the TROPICS Panama oil and dispersed oil spill sites. In: Proceedings 2003 International Oil Spill Conference. April 6-11, 2003. Vancouver, Canada. Washington, DC: American Petroleum Institute.

Webb, J.W., G.T. Tanner, and B.H. Koerth. 1981. Oil spill effects on smooth cordgrass in Galveston Bay, Texas. Contributions in Marine Science 24:107-114.Webb, J.W. 1988. Establishment of vegetation on oil-contaminated dunes. Shore and Beach, October. Pp. 20-23.

Webb, J.W., S.K. Alexander, and J.K. Winters. 1985. Effects of autumn application of oil on *Spartina alterniflora* in a Texas salt marsh. Environ. Poll., Series A 38(4):321-337.

Wesseling, I., A.J. Uychiaoco, P.M. Aliño, T. Aurin, and J.E. Vermaat. 1999. Damage recovery of four Philippine corals from short-term sediment burial. Marine Ecology Progress Series 176:11-15.

Wiese, F.K., W.A. Montevecchi, G.K. Davoren, F. Huettman, A.W. Diamond and J. Linke. 2001. Seabirds at risk around offshore oil platforms in the Northwest Atlantic. Marine Pollution Bulletin 42: 1285-1290.

Wiese, F.K. and G.J. Robertson. 2004. Assessing impacts of chronic oil discharges at sea on seabirds: a general oiled seabird mortality model applied to Eastern Canada. Journal of Wildlife Management 68: 627–638.

Wright, S.D., B.B. Ackerman, R.K. Bonde, C.A. Beck, and D.J. Banowetz. 1995. Analysis of watercraft-related mortality of manatees in Florida, 1979-1991. In: O'Shea, T.J., B.B. Ackerman, and H.F. Percival, eds. Population biology of the Florida manatee. National Biological Service Information and Technology Report 1. Pp. 259-268.

Wyers, S.C., H.R. Frith, R.E. Dodge, S.R. Smith, A.H. Knap, and T.D. Sleeter. 1986. Behavioral effects of chemically dispersed oil and subsequent recovery in *Diploria strigosa*. Marine Ecology 7:23-42.

Zeller, T., Jr. 2010. Drill ban means hard times for rig workers. Internet website: http://www.nytimes.com/2010/06/18/business/18rig.html?_r=1. Accessed June 29, 2010.

Zieman, J.C., R. Orth, R.C. Phillips, G. Thayer, and A. Thorhaug. 1984. The effects of oil on seagrass ecosystems. In: Cairns, J., Jr. and A.L. Buikema, Jr., eds. Restoration of habitats impacted by oil spills. Boston, MA: Butterworth Publishers.

APPENDIX C

BOEMRE-OSRA CATASTROPHIC RUN

APPENDIX C. BOEMRE-OSRA CATASTROPHIC RUN

A special Oil-Spill Risk Analysis (OSRA) run was conducted in order to estimate the impacts of a possible future catastrophic or high-volume, long-duration oil spill. Thus, assuming a hypothetical high-volume, long-duration oil spill occurred, this analysis emphasized modeling a spill that continued for 90 consecutive days, with each trajectory tracked for up to 120 days. The OSRA for this analysis was conducted for only the trajectories of oil spills from five hypothetical spill locations to various land segments. The probability of an oil spill contacting a specific land segment within a given time of travel from a certain location or spill point is termed a *conditional probability*; the condition being that a spill is assumed to have occurred. Each trajectory was allowed to continue for as long as 120 days. However, if the hypothetical spill contacted shoreline sooner than 30 days after the start of the spill, the spill trajectory was terminated, and the contact was recorded. Although, overall OSRA is designed for use as a risk-based assessment, for this analysis, only the *conditional probability*, the probability of contact to the resource, was calculated. The probability of a catastrophic spill occurring was not calculated; thus, the combination of the probability of a spill and the probability of contact to the resources from the hypothetical spill locations were not performed. Results from this trajectory analysis provide input to the final product by estimating where spills might travel on the ocean's surface and what land segments might be contacted if and when another catastrophic spill occurs, but it does not provide input on the probability of another catastrophic spill occurring.

OSRA Overview

The OSRA model, originally developed by Smith et al. (1982) and enhanced by this Agency over the years (Ji et al., 2002, 2004a, and 2004b), simulates oil-spill transport using model-simulated winds and ocean currents in the Gulf of Mexico. An oil spill on the ocean surface moves around by the complex surface ocean currents exerting a shear force on the spilled oil from below. In addition, the prevailing wind exerts an additional shear force on the spill from above, and the combination of the two forces causes the transportation of the oil spill away from its initial spill location. In the OSRA model, the velocity of a hypothetical oil spill is the linear superposition of the surface ocean current and the wind drift caused by the winds. The model calculates the movement of hypothetical spills by successively integrating time sequences of two spatially gridded input fields: the surface ocean currents and the sea-level winds. Thus, the OSRA model generates time sequences of hypothetical oil-spill locations—essentially, oil-spill trajectories.

At each successive time step, the OSRA model compares the location of the hypothetical spills against the geographic boundaries of shoreline. The frequencies of oil-spill contact are computed for designated oil-spill travel times (e.g., 3, 10, 30, or 120 days) by dividing the total number of oil-spill contacts by the total number of hypothetical spills initiated in the model from a given hypothetical spill location. The frequencies of oil-spill contact are the model-estimated probabilities of oil-spill contact. The OSRA model output provides the estimated probabilities of contact to segments of shoreline from the five launch points (LP) in the Gulf of Mexico, which are explained below.

There are factors not explicitly considered by the OSRA model that can affect the transport of spilled oil as well as the dimensions, volume, and nature of the oil spills contacting environmental resources or the shoreline. These include possible cleanup operations, chemical composition or biological weathering of oil spills, or the spreading and splitting of oil spills. The OSRA analysts have chosen to take a more environmentally conservative approach by presuming persistence of spilled oil over the selected time duration of the trajectories.

In the trajectory simulation portion of the OSRA model, many hypothetical oil-spill trajectories are produced by numerically integrating a temporally and spatially varying ocean current field, and superposing on that an empirical wind-induced drift of the hypothetical oil spills (Samuels et al., 1982). Collectively, the trajectories represent a statistical ensemble of simulated oil-spill displacements produced by a field of numerically derived winds and ocean currents. The winds and currents are assumed to be statistically similar to those that will occur in the Gulf during future offshore activities. In other words, the oil-spill risk analysts assume that the frequency of strong wind events in the wind field is the same as what will occur during future offshore activities. By inference, the frequencies of contact by the

simulated oil spills are the same as what could occur from actual oil spills during future offshore activities.

Another portion of the OSRA model tabulates the contacts by the simulated oil spills. A contact to shore will stop the trajectory of an oil spill; no re-washing is assumed in this model. After specified periods of time, the OSRA model will divide the total number of contacts to the coastline segments by the total number of simulated oil spills from each of the five LP's. These ratios are the estimated probabilities of oil-spill contact from offshore activities at that geographic location, assuming spill occurrence.

Conducting an oil-spill risk analysis needs detailed information on ocean currents and wind fields (Ji, 2004). The ocean currents used are numerically computed from an ocean circulation model of the Gulf of Mexico driven by analyzed meteorological forces (the near-surface winds and the total heat fluxes) and observed river inflow into the Gulf of Mexico (Oey et al., 2004; Oey, 2005). The models used are versions of the Princeton Ocean Model, which is an enhanced version of the earlier constructed Mellor-Blumberg Model.

The ocean model calculation was performed by Princeton University (Oey et al., 2004). This simulation covered the 7-year period, 1993 through 1999, and the results were saved at 3-hour intervals. This run included the assimilation of sea-surface altimeter observations to improve the ocean model results. The surface currents were then computed for input into the OSRA model, along with the concurrent wind field. The OSRA model used the same wind field to calculate the empirical wind drift of the simulated spills. The statistics for the contacts by the trajectories forced by the currents and winds were combined for the average probabilities.

Catastrophic OSRA Run Overview

A special OSRA run was conducted in order to estimate the impacts of a possible future catastrophic spill. Thus, assuming a hypothetical catastrophic oil spill occurred, this analysis emphasized modeling a spill that continued for 90 consecutive days with each trajectory tracked for up to 120 days. The OSRA for this analysis was conducted for only the trajectories of oil spills from five hypothetical spill locations to various land segments (**Figure C-1 and C-2**). The probability that an oil spill will contact a specific land segment within a given time of travel from a certain location or spill point is termed a *conditional probability*; the condition being that a spill is assumed to have occurred. Each trajectory was allowed to continue for as long as 120 days. However, if the hypothetical spill contacted shoreline sooner than 30 days after the start of the spill, the spill trajectory was terminated, and the contact was recorded. Although, overall the OSRA is designed for use as a risk-based assessment, for this analysis, only the *conditional probability*, the probability of contact to the resource, was calculated. The probability of a catastrophic spill occurring was not calculated, thus the combination of the probability of a spill and the probability of contact to the resources from the hypothetical spill locations was not performed. Results from this trajectory analysis provide input to the final product by estimating where spills might travel on the ocean's surface and what land segments might be contacted if and when another catastrophic spill occurs, but it does not provide input on the probability of another catastrophic spill occurring.

Trajectories of hypothetical spills were initiated every 1.0 day from each of the launch points over the simulation period from January 1, 1993, to December 31, 1998 (**Figure C-1**). The chosen number of trajectories per site was small enough to be computationally practical and large enough to reduce the random sampling error to an insignificant level. Also, the weather-scale changes in the winds are at least minimally sampled, with simulated spills started every 1.0 day.

These launch point locations were developed within the Gulf of Mexico region for the purpose of this analysis. Five launch points were identified and encompassed the approximate areas with the possibility of finding the largest oil volume within the following regions:

- Central Gulf of Mexico shelf area west of the Mississippi River;
- Central Gulf of Mexico shelf area east of the Mississippi River;
- Central Gulf of Mexico slope area;

- Western Gulf of Mexico shelf area; and
- Western Gulf of Mexico slope area.

Longitude	Latitude	Launch Point (LP)
-92.17851	28.98660	1
-88.15338	29.91388	2
-90.22203	27.31998	3
-96.76627	27.55423	4
-94.51836	27.51367	5

The methodology used for launch point selection is not part of the OSRA model in the manner it has been typically run for this Agency's spill analyses. Gulf of Mexico OCS Region geologists and engineers used the following methodology to select the five points. For each geologic play currently recognized, the undiscovered technically recoverable resource volume was allocated throughout the play area based on the likelihood of future oil discovery potential. The probability factor used to allocate undiscovered oil volumes to areas within the geologic play was based on the density of existing discoveries, the density of undrilled prospects on leased acreage, and the results from recent exploration activity. In areas where the potential for undiscovered technically recoverable resource volume exists for more than one geologic play, the oil volumes were aggregated. Results from the aggregation were used to identify five geographic areas of high potential for future oil discoveries: three in the Central Planning Area and two in the Western Planning Area of the Gulf of Mexico. Although these areas may encompass hundreds of square miles, the coordinates for the five launch points were selected qualitatively to correspond with the centroid of these areas. After their selection, the five points were given to the OSRA analysts for use with the OSRA model.

Additionally, the total estimated oil-contacted area of water was also determined. The OSRA model integrates the spill velocities (a linear superposition of surface ocean currents and empirical wind drift) by integrating in time to produce the spill trajectories. The time step selected was 1 hour to fully utilize the spatial resolution of the ocean current field and to achieve a stable set of trajectories. The velocity field was bilinearly interpolated from the 3-hour grid to get velocities at 1-hour intervals.

The trajectories simulated by the model represent only hypothetical pathways of oil slicks; they do not involve any direct consideration of cleanup, dispersion, or weathering processes that could alter the quantity or properties of oil that might eventually contact the environmental resource locations. However, an implicit analysis of weathering and spill degradation can be considered by choosing a travel time for the simulated oil spills when they contact environmental resource locations that represent the likely persistence of the oil slick on the water surface. Therefore, OSRA model trajectories were analyzed up to 120 days. Any spill contacts occurring during this elapsed time are reported in the probability tables. Conditional probabilities of contact with land segments within 120 days of travel time were calculated for each of the hypothetical spill sites.

The probability estimates were tabulated as 90-day groupings of the 120-day trajectories, as averages for the 6 years of the analysis from 1993 to 1998. These groupings were treated as seasonal probabilities that corresponded with quarters of the year: Winter, Q1 (January, February, and March); Spring, Q2 (April, May, and June); Summer, Q3 (July, August, and September); and Fall, Q4 (October, November, and December). These 3-month probabilities can be used to estimate the average number of land segments (counties/parishes) contacted during a spill, treated as one spill occurring each day for 90 days, within the quarter. The seasonal quarterly groupings take account of the differing meteorological and oceanographic conditions (wind and current patterns) during the year. The latest meteorological and oceanographic information in the Gulf of Mexico available to BOEMRE were for the years 1993-1998.

The area of ocean surface contacted by oil from the hypothetical spills was estimated by creating a grid of 1/6 degree longitude by 1/6 degree latitude. As the trajectories were computed, contact to the grid cells was tabulated. To estimate the area, the number of grid cells was multiplied by the approximate area of 342 square kilometers per grid cell. The number of grid cells and the approximate area of the ocean contacted by the spills were summarized at the same time intervals that were used for the land segment (county/parish boundary) tables (3, 10, 30, and 120 days).

Catastrophic OSRA Results and Discussion

It should be noted that the study area only extends somewhat into the Atlantic Ocean, where oil spills in the Gulf might be transported via the exiting Loop Current. However, on average, less than 0.5 percent of the simulated spills made it across the northern or southern Florida Straits boundary within 30 days, and only 1-2 percent within 120 days. The hypothetical spill trajectories from launch points in the western Gulf of Mexico (e.g., LP1, LP4, and LP5) have a much less chance of being transported through the Florida Straits than those in the central Gulf of Mexico (LP2 and LP3).

As one might expect, land segments closest to the spill sites had the greatest risk of contact. As the model run duration increases, more of the shoreline segments could have meaningful probabilities of contact (≥0.5%) (See **Tables C-1 through C-5** for the probabilities expressed as percent chance of one or more offshore spills ≥1,000 bbl contacting the areas noted in **Figure C-2**.). It should be reiterated that these are *conditional probabilities*; the condition being that a spill is assumed to have occurred. The longer transit times up to 120 days allowed by the model enable hypothetical spills to reach the environmental resources and the shoreline from more distant spill locations. With increased travel time, the complex patterns of wind and ocean currents produce eddy-like motions of the oil spills and multiple opportunities for a spill to make contact with shoreline segments. For some launch points and for the travel times greater than 30 days, the probability of contact to land decreases very slowly or remains constant because the early contacts to land have occurred within 30 days, and the trajectories that have not contacted land within 30 days will remain at sea for 120 days or more.

To summarize the differences between the LP's, a chart showing the estimated square area of each launch point for the 6-day intervals is shown (see **Figures C-3 through C-7** corresponding to LP's 1-5, respectively). The differences between the estimated spill areas from each LP can be explained by meteorological and oceanographic conditions.

- LP1—CPA, shelf area, west of the Mississippi River Delta, offshore south-central Louisiana, deepwater. Launch Point 1 is located near the Louisiana coast, and the fall circulation results in persistent and recurring coastal current from Louisiana waters toward Texas waters.
- LP2—CPA, shelf edge area, east of the Mississippi River Delta, south of the Alabama-Mississippi border, ultra-deepwater. Launch Point 2 is located near the Mississippi River Delta on the eastern side. The trajectories contact the coastline of Louisiana, Mississippi, Alabama, and Florida. Many of the trajectories are forced offshore by the wind drift and interact with the Loop Current and Loop Current eddies.
- LP3—CPA, shelf area, west of the Mississippi River delta, due south of New Orleans, deepwater. Launch Point 3 is located relatively far offshore and west of the Mississippi River Delta. The estimated area contacted by the spill is the largest of all the selected points, and the trajectories are influenced by the deepwater Loop Current eddies and offshore currents.
- LP4—WPA, shelf area, deepwater. Launch Point 4 is near the Texas coast in the western Gulf of Mexico. The trajectories from this launch point frequently contact land. The coastal flow near Texas, but to the south of the U.S./Mexico border, has a high fraction of northward currents, the wind is relatively persistent with a westward component, and the trajectories remain in a relatively smaller area.
- LP5—WPA, slope area, ultra-deepwater. Launch Point 5 is in the western Gulf of Mexico between the coast (LP4) and the central Gulf (LP3). The trajectories are forced by the Loop Current eddies that are somewhat weaker in this part of the Gulf of Mexico because these eddies dissipate kinetic energy as they drift to the west from their original separation zone.

References Cited

Ji, Z.-G. 2004. Use of physical sciences in support of environmental management. Environmental Management 34(2). Pp. 159-169.

Ji, Z.-G., W.R. Johnson, C.F. Marshall, G.B. Rainey, and E.M. Lear. 2002. Oil-spill risk analysis: Gulf of Mexico outer continental shelf (OCS) lease sales, Central Planning Area and Western Planning Area, 2003-2007, and Gulfwide OCS program, 2003-2042. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS Report MMS 2002-032. 61 pp.

Ji, Z.-G., W.R. Johnson, and C.F. Marshall. 2004a. Deepwater oil-spill modeling for assessing environmental impacts. Coastal Environment V. Southampton, MA: WIT Press. Pp. 349-358.

Ji, Z.-G., W.R. Johnson, C.F. Marshall, and E.M. Lear. 2004b. Oil-spill risk analysis: Contingency planning statistics for Gulf of Mexico OCS activities. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA. OCS Report MMS 2004-026. 62 pp.

Oey, L.-Y. 2005. Circulation model of the Gulf of Mexico and the Caribbean Sea: Development of the Princeton Regional Ocean Forecast (& Hindcast) System—PROFS and Hindcast experiment for 1992-1999: Final report. U.S. Dept. of the Interior, Minerals Management Service, Environmental Division, Herndon, VA. OCS Study MMS 2005-049. 174 pp.

Oey, L.-Y., P. Hamilton, and H.C.-Lee. 2004. Modeling and data analyses of circulation processes in the Gulf of Mexico: Final report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-074. 129 pp.

Samuels, W.B., N.E. Huang, and D.E. Amstutz. 1982. An oil spill trajectory analysis model with a variable wind deflection angle. Ocean Engineering 9:347-360.

Smith, R.A., J.R. Slack, T. Wyant, and K.J. Lanfear. 1982. The oil spill risk analysis model of the U.S. Geological Survey. U.S. Dept. of the Interior, Geological Survey Professional Paper 1227.

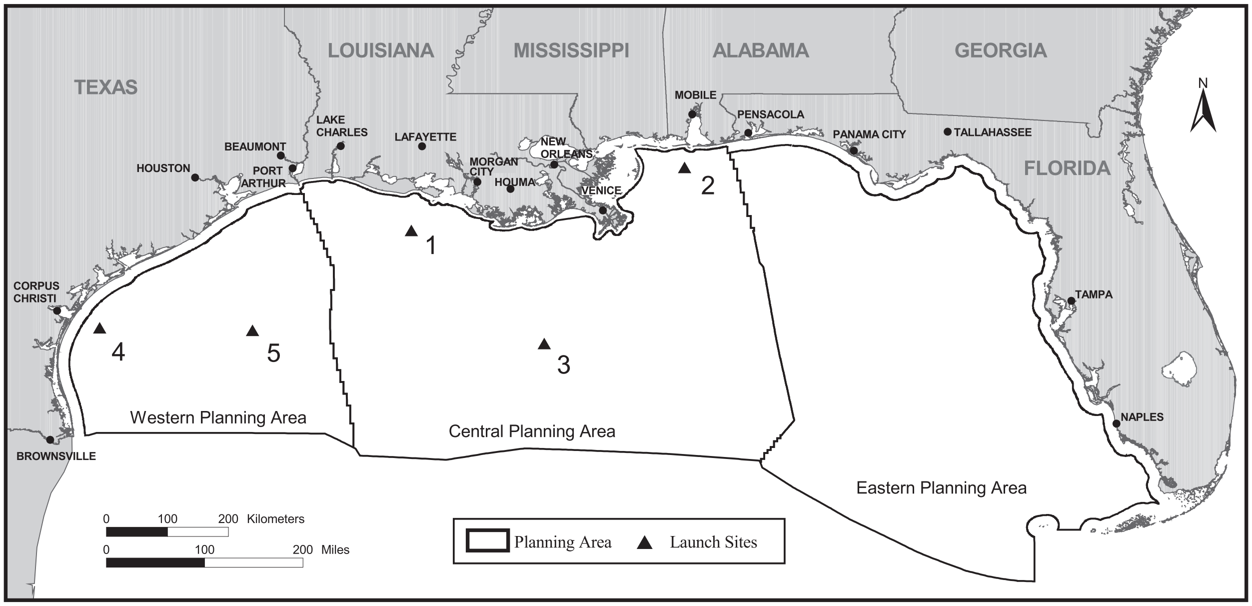

Figure C-1. Location of Five Hypothetical Oil-Spill Launch Points for OSRA within the Study Area.

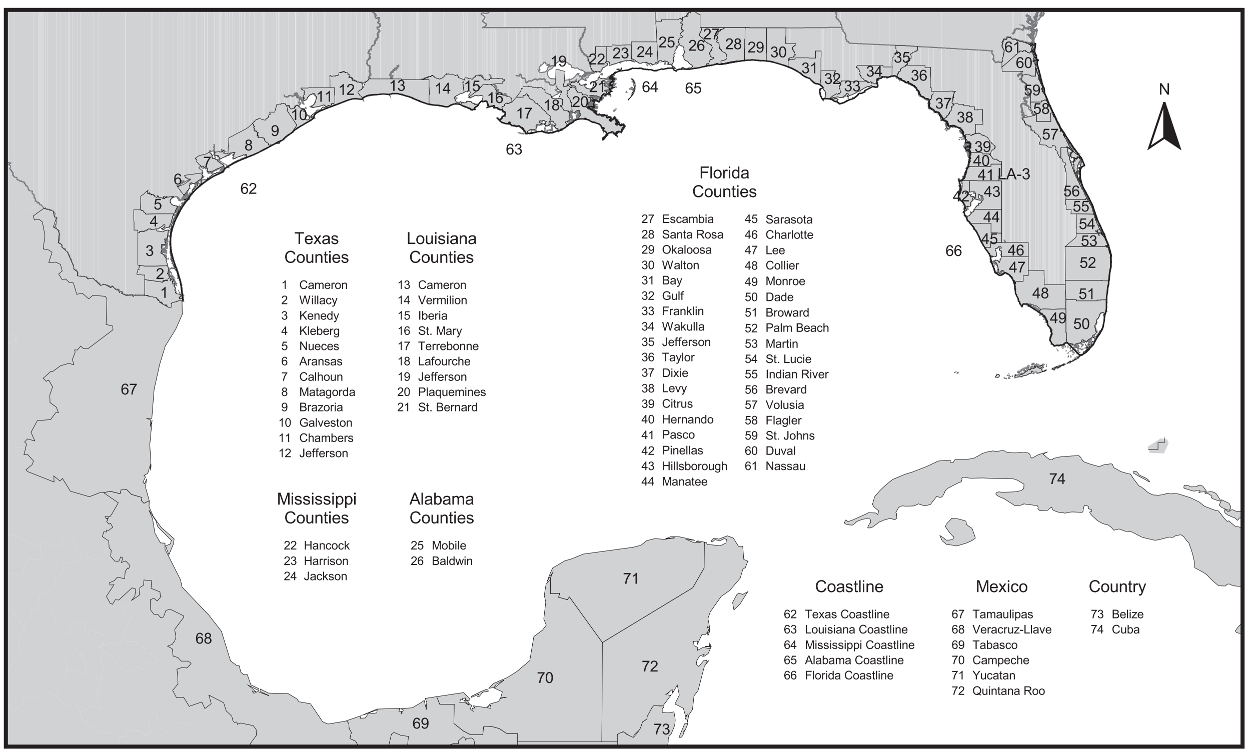

Figure C-2. Locations of Parishes, Counties, and Coastlines Examined in the Special OSRA Run Conducted in Order to Estimate the Impacts of a Possible Future Catastrophic Spill.

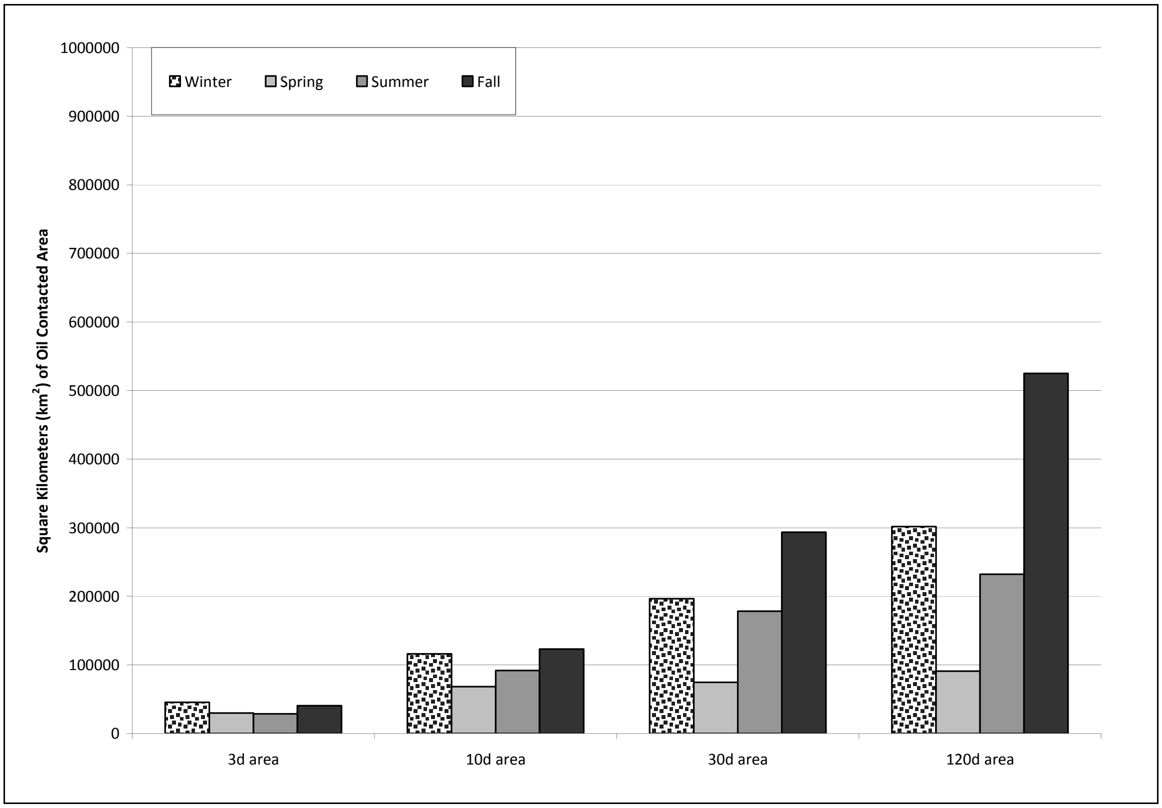

Figure C-3. Estimated Square Area of Launch Point One (LP 1) for 3, 10, 30, and 120 Days in Winter, Spring, Summer, and Fall.

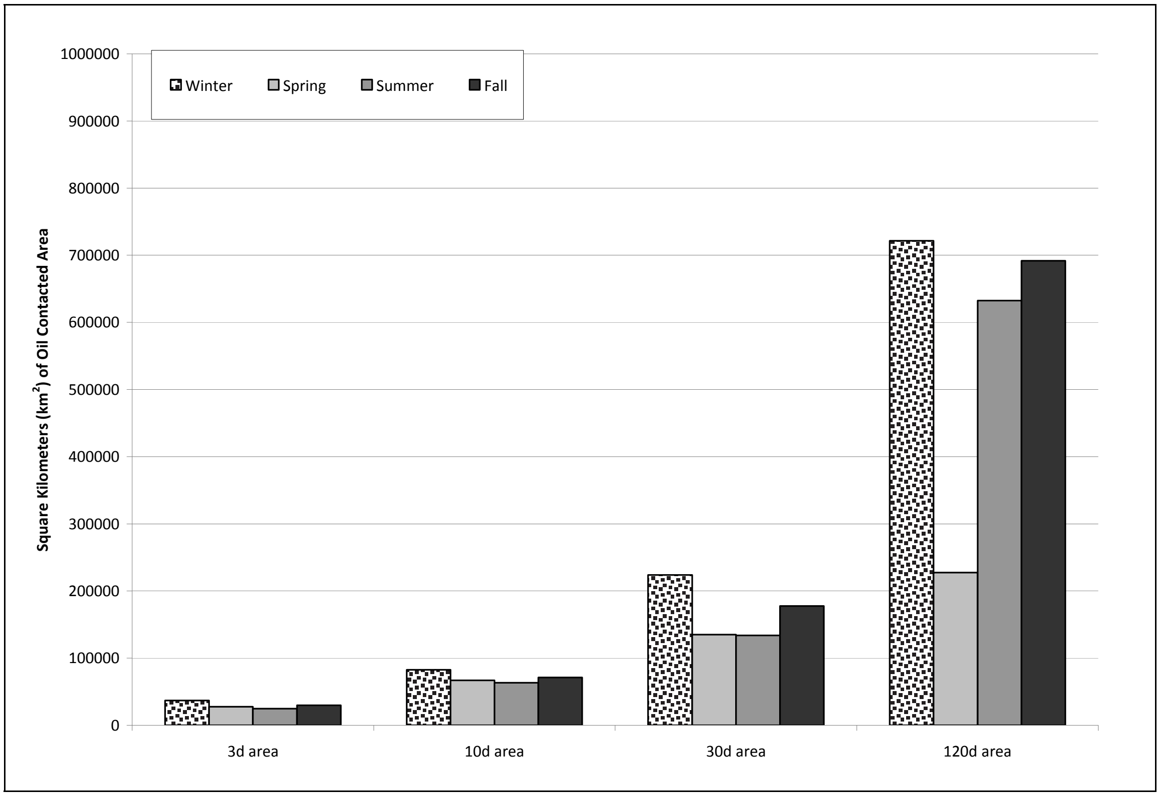

Figure C-4. Estimated Square Area of Launch Point Two (LP 2) for 3, 10, 30, and 120 Days in Winter, Spring, Summer, and Fall.

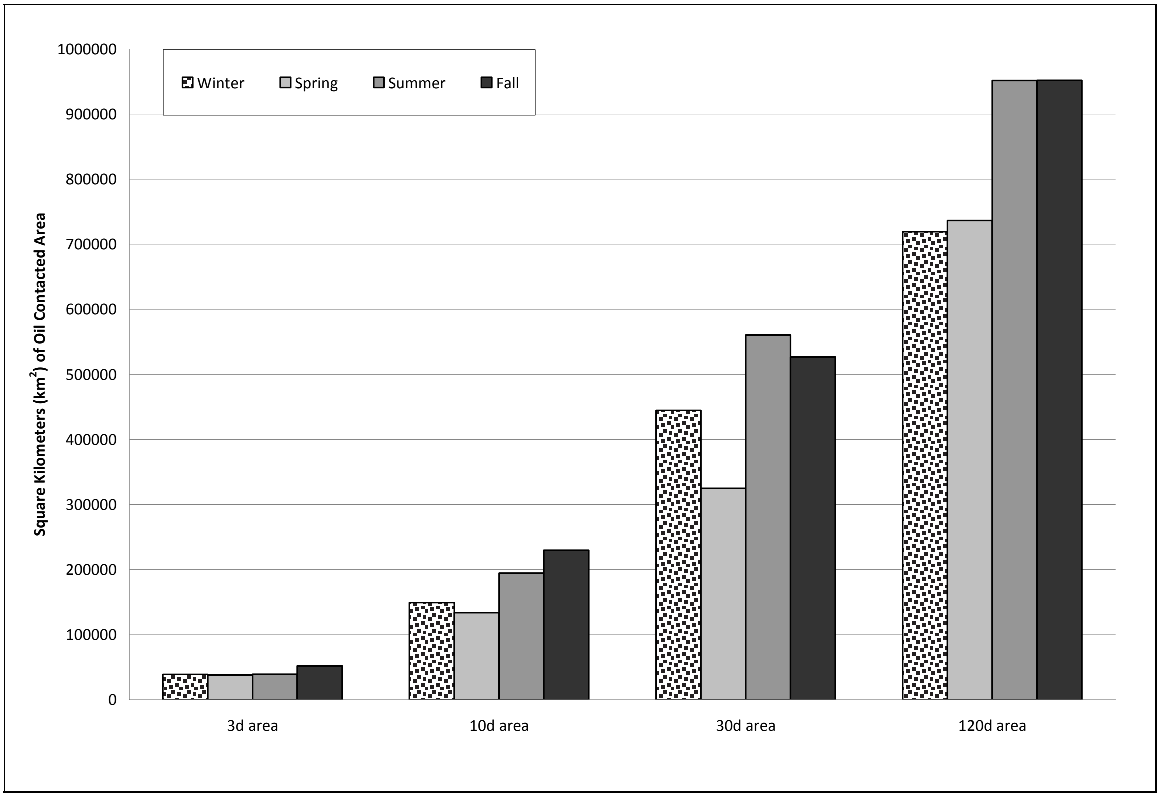

Figure C-5. Estimated Square Area of Launch Point Three (LP 3) for 3, 10, 30, and 120 Days in Winter, Spring, Summer, and Fall.

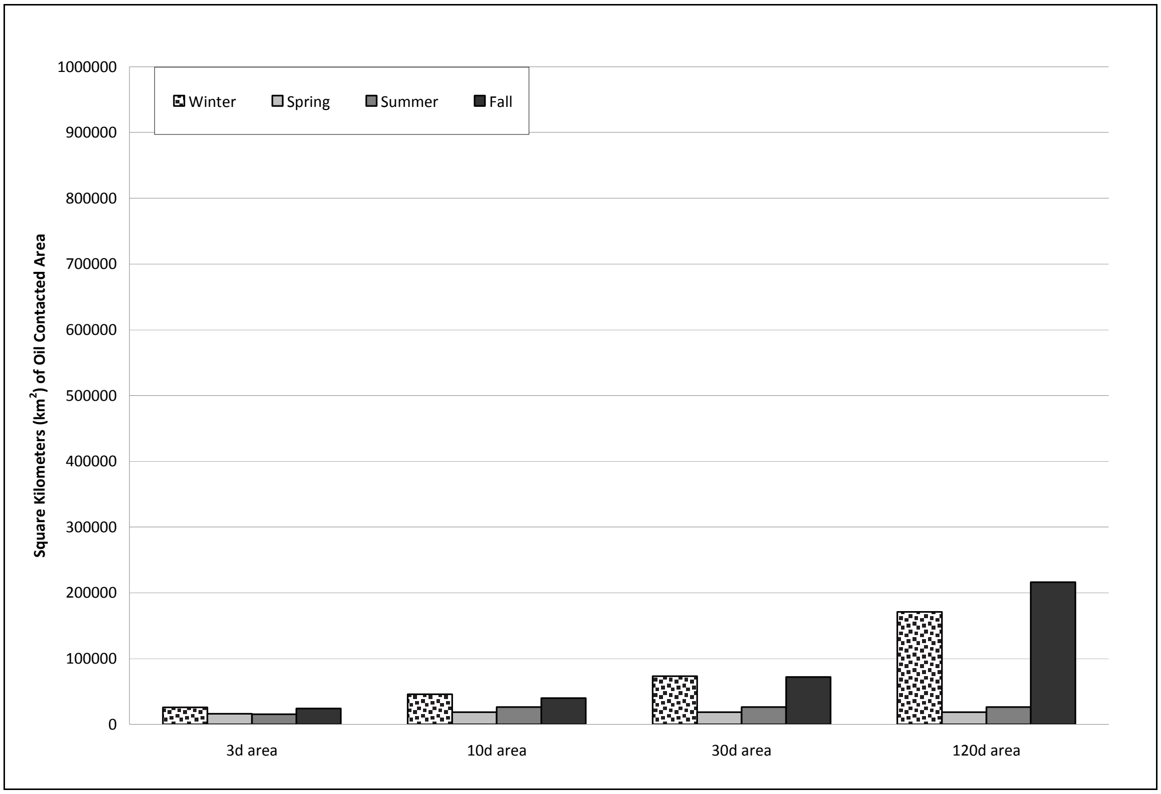

Figure C-6. Estimated Square Area of Launch Point Four (LP 4) for 3, 10, 30, and 120 Days in Winter, Spring, Summer, and Fall.

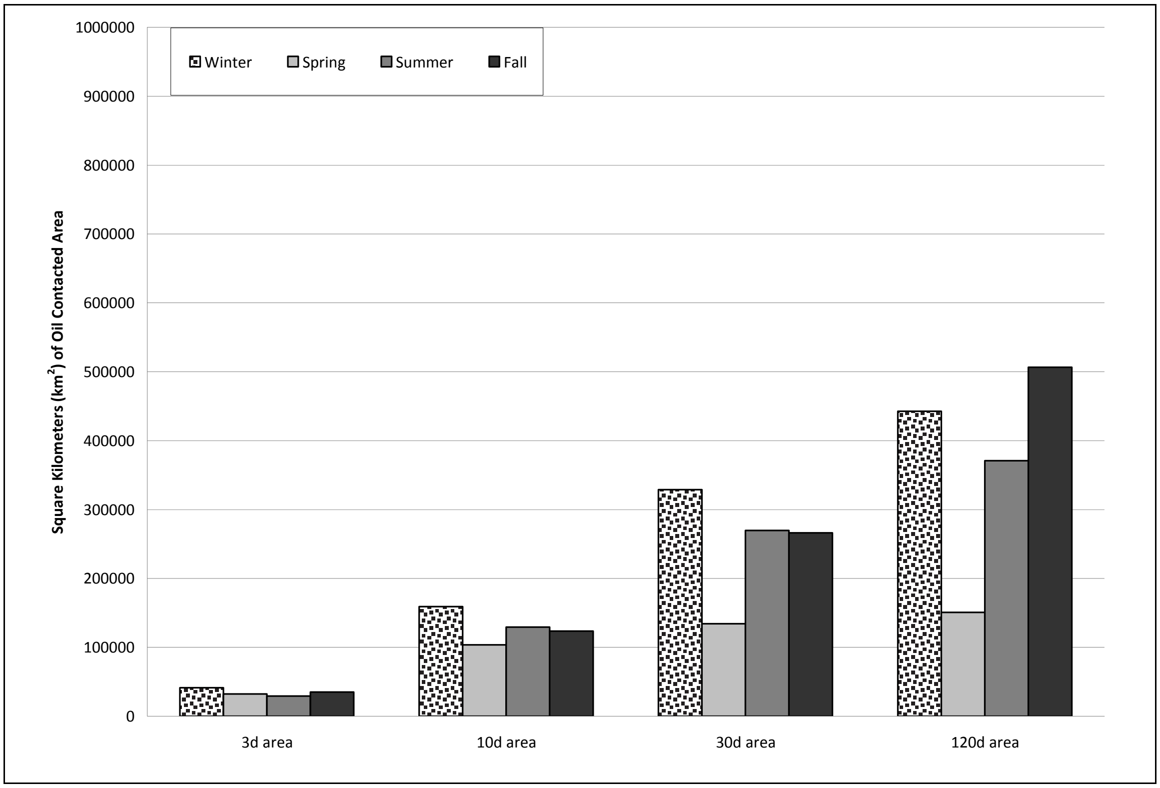

Figure C-7. Estimated Square Area of Launch Point Five (LP 5) for 3, 10, 30, and 120 Days in Winter, Spring, Summer, and Fall.

Table C-1

Conditional Probabilities Expressed as Percent Chance that an Oil Spill Starting at Launch Point One Will Contact a Certain Parish, County, or Coastline within 120 Days

	Season	Winter				Spring				Summer				Fall			
	Day	3	10	30	120	3	10	30	120	3	10	30	120	3	10	30	120
ID	Name	Percent Chance															
1	Cameron, TX	-	-	1	2	-	-	-	-	-	-	-	1	-	-	-	2
2	Willacy, TX	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
3	Kenedy, TX	-	-	1	3	-	-	-	-	-	-	1	1	-	-	2	4
4	Kleberg, TX	-	-	-	1	-	-	-	1	-	-	1	1	-	-	1	3
5	Nueces, TX	-	-	1	4	-	-	-	-	-	-	1	2	-	-	1	3
6	Aransas, TX	-	-	2	4	-	-	-	-	-	-	2	2	-	-	2	4
7	Calhoun, TX	-	-	5	10	-	-	-	-	-	-	4	4	-	-	2	3
8	Matagorda, TX	-	1	13	17	-	-	1	1	-	-	3	4	-	1	9	11
9	Brazoria, TX	-	1	9	10	-	1	3	3	-	-	4	6	-	-	6	6
10	Galveston, TX	-	2	9	11	-	2	8	9	-	2	12	15	-	1	9	9
11	Chambers, TX	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
12	Jefferson, TX	-	2	5	6	-	5	9	9	-	2	9	10	-	3	6	6
13	Cameron, LA	2	10	13	15	5	35	41	41	-	7	18	20	2	13	16	19
14	Vermilion, LA	4	9	10	10	8	22	24	24	1	9	12	12	4	8	9	9
15	Iberia, LA	1	2	3	3	1	5	6	6	-	5	7	7	1	2	3	3
16	St. Mary, LA	-	1	1	1	-	1	1	1	-	-	-	-	-	-	-	-
17	Terrebonne, LA	-	1	1	1	-	2	2	2	-	-	5	6	-	1	1	1
18	Lafourche, LA	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
19	Jefferson, LA	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
21	St. Bernard, LA	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
62	Texas Coastline	-	6	45	68	-	8	23	24	-	5	37	47	-	6	38	52
63	Louisiana Coastline	8	23	28	30	14	64	75	76	2	21	43	49	6	23	30	32
64	Mississippi Coastline	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
67	Tamaulipas, Mexico	-	-	-	1	-	-	-	-	-	-	2	2	-	-	1	3

Note: Values of <0.5% are indicated by “-”. Any areas where the percent chance within 120 days of all seasons are all <0.5% are not shown. See Figure C-1 for the location of Launch Point One. See Figure C-2 for the location of the named land areas.

Table C-2

Conditional Probabilities Expressed as Percent Chance that an Oil Spill Starting at Launch Point Two Will Contact a Certain Parish, County, or Coastline within 120 Days

	Season	Winter				Spring				Summer				Fall			
	Day	3	10	30	120	3	10	30	120	3	10	30	120	3	10	30	120
ID	Name	Percent Chance															
1	Cameron, TX	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
2	Willacy, TX	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3	Kenedy, TX	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
4	Kleberg, TX	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
7	Calhoun, TX	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
8	Matagorda, TX	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	2
9	Brazoria, TX	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
10	Galveston, TX	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-
12	Jefferson, TX	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
13	Cameron, LA	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
14	Vermilion, LA	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
17	Terrebonne, LA	-	-	3	4	-	-	-	-	-	-	-	1	-	-	-	1
18	Lafourche, LA	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
19	Jefferson, LA	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
20	Plaquemines, LA	1	14	21	23	-	3	4	6	1	8	20	25	2	21	27	28
21	St. Bernard, LA	-	4	5	5	-	1	2	3	1	7	14	16	-	8	9	10
22	Hancock, MS	-	1	2	4	-	2	2	2	-	2	3	3	1	3	5	5
23	Harrison, MS	2	3	4	5	-	4	4	4	1	3	4	4	1	2	3	3
24	Jackson, MS	7	11	11	13	5	11	12	12	1	3	4	4	6	12	13	14
25	Mobile, AL	11	14	14	15	11	16	17	17	4	8	9	10	8	11	12	13
26	Baldwin, AL	4	7	7	9	6	14	16	17	1	8	10	10	1	2	2	3
27	Escambia, FL	-	1	1	2	1	5	11	13	1	3	5	6	-	-	1	1
29	Okaloosa, FL	-	-	-	1	-	1	2	3	-	-	1	1	-	-	-	-
30	Walton, FL	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	1
31	Bay, FL	-	-	-	1	-	2	3	5	-	-	1	2	-	-	-	-
32	Gulf, FL	-	-	-	-	-	1	3	5	-	-	1	1	-	-	-	-
33	Franklin, FL	-	-	-	-	-	-	-	3	-	-	1	2	-	-	-	-
34	Wakulla, FL	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
36	Taylor, FL	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
38	Levy, FL	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
49	Monroe, FL	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
50	Dade, FL	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
62	Texas Coastline	-	-	-	7	-	-	-	-	-	-	-	5	-	-	1	6
63	Louisiana Coastline	2	18	29	37	-	4	6	9	1	15	34	43	2	29	39	41
64	Mississippi Coastline	9	15	17	22	5	16	18	19	3	7	11	12	7	16	21	22
65	Alabama Coastline	15	21	21	24	18	30	34	34	5	16	19	20	9	13	14	15
66	Florida Coastline	-	2	2	6	1	10	20	36	1	3	10	14	-	-	1	2
67	Tamaulipas, Mexico	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1

Note: Values of <0.5% are indicated by "-". Any areas where the percent chance within 120 days of all seasons are all <0.5% are not shown. See Figure C-1 for the location of Launch Point Two. See Figure C-2 for the location of the named land areas.

Table C-3

Conditional Probabilities Expressed as Percent Chance that an Oil Spill Starting at Launch Point Three Will Contact a Certain Parish, County, or Coastline within 120 Days

	Season	Winter				Spring				Summer				Fall			
	Day	3	10	30	120	3	10	30	120	3	10	30	120	3	10	30	120
ID	Name	Percent Chance															
1	Cameron, TX	-	-	-	2	-	-	-	-	-	-	-	2	-	-	-	2
2	Willacy, TX	-	-	-	3	-	-	-	-	-	-	-	2	-	-	-	3
3	Kenedy, TX	-	-	-	8	-	-	-	1	-	-	-	9	-	-	-	5
4	Kleberg, TX	-	-	1	6	-	-	-	-	-	-	-	4	-	-	1	6
5	Nueces, TX	-	-	1	6	-	-	-	-	-	-	-	2	-	-	1	2
6	Aransas, TX	-	-	-	5	-	-	-	1	-	-	-	3	-	-	-	2
7	Calhoun, TX	-	-	1	6	-	-	-	-	-	-	-	6	-	-	1	4
8	Matagorda, TX	-	-	2	17	-	-	3	4	-	-	-	11	-	-	1	6
9	Brazoria, TX	-	-	3	12	-	-	1	3	-	-	2	8	-	-	1	5
10	Galveston, TX	-	-	3	10	-	-	3	6	-	-	2	5	-	-	1	4
12	Jefferson, TX	-	-	1	4	-	-	7	9	-	-	1	1	-	-	-	2
13	Cameron, LA	-	-	1	4	-	-	11	12	-	1	1	4	-	-	-	4
14	Vermilion, LA	-	-	1	2	-	-	5	6	-	1	1	2	-	-	-	-
15	Iberia, LA	-	-	-	1	-	-	4	4	-	-	-	-	-	-	-	-
17	Terrebonne, LA	-	1	2	3	-	4	12	14	-	-	-	2	-	-	-	-
18	Lafourche, LA	-	-	1	1	-	2	8	10	-	-	1	2	-	-	-	-
19	Jefferson, LA	-	-	-	1	-	-	2	2	-	-	1	1	-	-	-	-
20	Plaquemines, LA	-	-	-	1	-	2	10	12	-	-	1	2	-	-	-	-
24	Jackson, MS	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
26	Baldwin, AL	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
31	Bay, FL	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
33	Franklin, FL	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
49	Monroe, FL	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
50	Dade, FL	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
62	Texas Coastline	-	-	12	78	-	-	14	24	-	-	6	54	-	-	4	41
63	Louisiana Coastline	-	1	6	14	-	9	52	60	-	1	4	13	-	-	-	6
64	Mississippi Coastline	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
65	Alabama Coastline	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
66	Florida Coastline	-	-	-	1	-	-	1	4	-	-	-	2	-	-	-	2
67	Tamaulipas, Mexico	-	-	-	4	-	-	-	1	-	-	-	10	-	-	-	10
68	Veracruz-Llave, Mexico	-	-	-	-	-	-	-	-	-	-	1	7	-	-	-	1
69	Tabasco, Mexico	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-

Note: Values of <0.5% are indicated by "-". Any areas where the percent chance within 120 days of all seasons are all <0.5% are not shown. See Figure C-1 for the location of Launch Point Three. See Figure C-2 for the location of the named land areas.

Table C-4

Conditional Probabilities Expressed as Percent Chance that an Oil Spill Starting at Launch Point Four Will Contact a Certain Parish, County, or Coastline within 120 Days

	Season	Winter				Spring				Summer				Fall			
	Day	3	10	30	120	3	10	30	120	3	10	30	120	3	10	30	120
ID	Name	Percent Chance															
1	Cameron, TX	1	3	3	3	-	-	-	-	-	-	-	-	-	2	3	3
2	Willacy, TX	3	4	4	4	1	1	1	1	-	1	1	1	3	7	8	8
3	Kenedy, TX	10	22	23	23	7	9	9	9	3	9	9	9	10	21	22	23
4	Kleberg, TX	9	14	15	16	12	14	14	14	9	17	17	17	7	13	14	14
5	Nueces, TX	10	16	17	18	21	26	26	26	8	17	18	18	11	16	17	17
6	Aransas, TX	11	15	16	16	28	33	33	33	17	26	26	26	9	12	13	13
7	Calhoun, TX	7	12	13	14	12	15	15	15	18	25	26	26	7	11	12	12
8	Matagorda, TX	1	3	3	4	1	2	2	2	-	2	2	2	-	1	2	3
9	Brazoria, TX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
62	Texas Coastline	51	90	94	98	82	99	100	100	56	98	100	100	48	84	91	93
67	Tamaulipas, Mexico	-	1	2	2	-	-	-	-	-	-	-	-	-	-	1	1

Note: Values of <0.5% are indicated by "-". Any areas where the percent chance within 120 days of all seasons are all <0.5% are not shown. See Figure C-1 for the location of Launch Point Four. See Figure C-2 for the location of the named land areas.

Table C-5

Conditional Probabilities Expressed as Percent Chance that an Oil Spill Starting at Launch Point Five Will Contact a Certain Parish, County, or Coastline within 120 Days

	Season	Winter				Spring				Summer				Fall			
	Day	3	10	30	120	3	10	30	120	3	10	30	120	3	10	30	120
ID	Name	Percent Chance															
1	Cameron, TX	-	-	2	4	-	-	-	-	-	-	2	3	-	-	3	5
2	Willacy, TX	-	-	1	4	-	-	-	-	-	-	2	3	-	-	2	3
3	Kenedy, TX	-	1	8	14	-	-	1	1	-	-	4	7	-	-	6	9
4	Kleberg, TX	-	-	5	7	-	1	2	2	-	-	1	3	-	-	4	5
5	Nueces, TX	-	1	5	9	-	1	2	2	-	-	1	1	-	-	3	5
6	Aransas, TX	-	1	5	10	-	-	3	3	-	-	2	3	-	-	4	6
7	Calhoun, TX	-	2	10	20	-	3	11	12	-	-	7	9	-	1	5	7
8	Matagorda, TX	-	1	8	14	-	18	29	30	-	2	12	21	-	2	9	15
9	Brazoria, TX	-	-	3	4	-	9	13	13	-	-	7	12	-	1	4	6
10	Galveston, TX	-	1	2	4	-	3	11	13	-	-	5	12	-	1	2	3
12	Jefferson, TX	-	-	-	1	-	-	12	15	-	-	1	4	-	-	-	1
13	Cameron, LA	-	-	-	1	-	1	5	6	-	-	6	8	-	-	-	-
14	Vermilion, LA	-	-	-	-	-	-	2	3	-	-	1	2	-	-	-	-
20	Plaquemines, LA	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
62	Texas Coastline	-	7	50	91	-	35	85	90	-	2	43	79	-	5	43	65
63	Louisiana Coastline	-	-	-	1	-	1	8	9	-	-	8	11	-	-	-	-
67	Tamaulipas, Mexico	-	-	1	6	-	-	-	-	-	-	3	7	-	-	2	11
68	Veracruz-Llave, Mexico	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-

Note: Values of <0.5% are indicated by "-". Any areas where the percent chance within 120 days of all seasons are all <0.5% are not shown. See Figure C-1 for the location of Launch Point Five. See Figure C-2 for the location of the named land areas.

APPENDIX D

DEEPWATER HORIZON EVENT CHRONOLOGY

APPENDIX D. *DEEPWATER HORIZON* EVENT CHRONOLOGY

On April 20, 2010, the *Deepwater Horizon* (DWH) mobile offshore drilling unit (MODU), a dynamically positioned semisubmersible exploratory drilling rig owned by Transocean Ltd. and leased to BP Public Liability Company, exploded at approximately 9:48 p.m. CDT and began to burn uncontrollably. The *Deepwater Horizon* was in the process of temporarily abandoning an exploratory well that had reached a total depth below mudline of approximately 13,000 feet (ft) (3,962 meters [m]; 2.46 miles [mi]; 3.96 kilometers [km]). British Petroleum's (BP's) exploration prospect, Macondo, was located on a lease acquired in 2006 (OCS-G 32306) in Mississippi Canyon Block 252 located about 53 mi (85 km) southeast of the nearest land at the end of the Mississippi River's "birdfoot" delta. BP as the lease owner had contracted with Transocean to drill the well to BP's specifications for $533,000 per day (Urbina, 2010).

In the immediate aftermath of the explosion and fire, dozens of survivors were recovered from the water and from emergency escape craft and were airlifted to area medical facilities onshore. In the hours after the explosion, the U.S. Coast Guard (USCG) managed a firefighting effort among vessels on the scene. The rig burned for 36 hours and, after a final explosion, sank on April 22, 2010, at 10:22 a.m. CDT in 4,992 ft (1,521 m) of water with approximately 700,000 gallons of diesel fuel on board. Eleven members of the 126-member crew were unaccounted for. After a search mission with 28 aircraft and vessels reported to have covered 5,375 mi^2 (13,920 km^2) (Polson, 2010), on April 23, the 11 crew members were presumed dead by the USCG. Their bodies were never found. The spill that resulted from the rig's explosion and sinking before the well was finally capped on July 15, 2010, would become the largest spill caused by a blowout (**Table D-1**) and was almost twice as large as the largest tanker spill (**Table D-2**).

On April 24, 2010, search and recovery vessels on site reported oil at the surface, which was later determined to be from two subsurface leaks; one from the collapsed riser assembly lying on the sea bottom at the point of detachment from the sunken rig and one from the top of the blowout preventer (BOP) at a point where the riser ruptured at a kink that formed as it folded over after the rig sank. BP believed that about 85 percent of the leak was coming from the end of the riser lying on the sea bottom, with the rest coming from the kinked riser above the BOP. The first estimate of a spill rate—1,000 barrels (bbl)/day—was made by BP and the USCG on April 24, 2010. From this first estimate, disagreements were reported in print media, but the trend line was that all subsequent estimates were consistently higher (see "Amount of Oil Spilled" below).

BP managed well control operations with a command center located at their facilities in Houston, Texas, from where engineers could monitor and control activity on the scene. Efforts to activate the BOP by remotely operated vehicles (ROV's), among them the 3-ton, 220-horsepower *Millennium Plus*, began on April 25 and were abandoned as ineffective during the first week in May. Webb (2010) reported on July 18, 2010, that field modifications to the BOP were made by Transocean in 2005, the design drawings for which were not readily available, making it difficult for engineers to understand its configuration with ROV's. On April 28, 2010, Robertson (2010) reported that a third leak had been discovered in the riser near the wellhead. This leak was stopped on May 5 when an ROV closed a shut-off valve (Mowbray, 2010). Also on April 28, the National Oceanic and Atmospheric Administration (NOAA) estimated a leak rate of 5,000 bbl/day based on observations made in flights over the slick and by studying its trajectory.

The first in-situ surface burns of oil were carried out on April 28, 2010. Surface burns first required vessels to skim the water surface with floating, fireproof booms to corral oil into concentrated areas. Collected slicks were then set alight with an improvised gasoline torch system. Under 40 CFR 300.323, a "spill of national significance" may be declared by the Administrator of the U.S. Environmental Protection Agency (USEPA) for discharges occurring in the inland zone and by the Commandant of the USCG for discharges occurring in the coastal zone. On April 29, 2010, when it was clear the sinking caused an uncontrolled blowout, Department of Homeland Security Secretary, Janet Napolitano, declared the event a spill of national significance to allow response personnel and equipment from other parts of the country to be more easily mobilized and moved into the area. On the same day, the Governor of Louisiana, Bobby Jindal, declared a state of emergency. BP mobilized two MODU's during the first week of May 2010 to drill relief wells as the final stage for shutting down the well. Transocean's

Development Driller III began the first relief well about a one-half mile from the Macondo well on May 2, 2010. A second relief well was begun by Transocean's *Development Driller II* on May 16, 2010.

The Oil Pollution Act of 1990 places liability for spills on the lease operator and charges the Federal Government with oversight for spill-response activity, the details for which were unspecified. Soon after the explosion and sinking of the *Deepwater Horizon* evidence for an oil spill was observed on April 24.

On April 24, a Unified Incident Command (UIC) Center was first established in Robert, Louisiana. On June 15, plans were announced to move UIC from Robert to New Orleans, Louisiana. The UIC managed response operations, prepared maps and status reports, maintained an official *Deepwater Horizon* Response website, and provided a forum for consensus decisionmaking among the organizations responsible for spill response. The UIC had Incident Command Centers in Houma, Louisiana; Mobile, Alabama; and Miami, Florida. Together, these Centers were referred to as the Unified Area Command. On May 1, 2010, Admiral Thad Allen (USCG, retired) was designated by Department of Homeland Security Secretary Napolitano as National Incident Commander. Each Federal agency involved with spill-response activity reported to the National Incident Commander. Rear Admiral Mary Landry (USCG) was responsible for on-scene offshore response activity and Administrator Lisa Jackson (USEPA) was responsible for response activity onshore. The UIC included management and staff representatives from the Department of Homeland Security, Department of Defense, Department of the Interior (DOI), Department of Commerce (DOC), USEPA, and other Federal departments and agencies, in addition to BP as the responsible party. As many as 2,400 people staffed the Unified Area Command in August that dropped quickly to 550 people in September (White, 2010). **Table D-3** shows the number of people managed by UIC during spill response activities from April 2010 through January 2011. The National Incident Commander responsibilities were transferred from Thad Allen to USCG Rear Admiral Paul Zukunft on October 1, 2010 (White, 2010)**.**

Early Response and Containment Efforts

On April 30, the Department of Defense approved a request by USCG for two C-130 aircraft with Modular Aerial Spray Systems to begin application of dispersants at the surface (The White House Blog, 2010), and also on April 30, UIC authorized a new technique to break up spilling oil before it reached the surface by using an ROV to inject subsurface dispersant into the flow stream at the top of the BOP. An application of 9 gallons of dispersant per minute was applied (Gelsi, 2010). The USEPA Administrator, Lisa Jackson, was concerned about the open-ended use of dispersant chemicals designed to break oil into particles that can be digested by bacteria. The spill was requiring BP to use unprecedented amounts of dispersant. One dispersant, *Corexit 9500* (*Corexit),* was available in large quantities; therefore, BP was deploying it on the surface and at the subsurface spill site. On May 20, USEPA and the Department of Homeland Security gave BP 24 hours to find a less biotoxic alternative and to apply the new dispersant(s) within 48 hours of submitting the list of alternatives, or explain why they could not do so (U.S. Dept. of Homeland Security and USEPA, 2010). At the time, it was believed that *Corexit* may have been one of the more biotoxic dispersant options among those available. BP responded by letter on May 20 that makers of other dispersants would not be able to supply large volumes of alternative dispersants for 10-14 days and intended to keep using *Corexit*. On May 24, USEPA reauthorized BP to inject *Corexit* into the spill stream at the wellhead, but determined that BP's response to USEPA's directive to find substitute dispersants was "insufficient" and that surface applications of dispersant be minimized (Cart and Simon, 2010). On May 26, 2010, USEPA (2010) informed BP that, given the lack of alternatives, the Agency would not stop BP from using *Corexit*, but that BP would have to "significantly" reduce dispersant use and to look for alternatives for *Corexit*. As of July 15, 2010, the last time subsurface dispersants were used, the Unified Area Command reported that 771,272 gallons were injected at the wellhead. As of July 20, 2010, the last date surface dispersants were used, the Unified Area Command reported (*Deepwater Horizon* Response, 2010a) that BP had sprayed 1,072,514 gallons of dispersant on the surface of the water.

On May 5, 2010, a barge towed a purpose-built 40 ft x 24 ft x 14 ft (12 m x 7 m x 4 m) 100-ton steel Cofferdam containment dome to the site of the spill. At the top of the dome, there was a riser system to carry leaking oil to the *Discoverer Enterprise* drillship at the rate of ~15,000 bbl/day. The semisubmersible *Helix Q4000*, a dynamically positioned MODU specifically designed for well intervention, began to lower the Cofferdam containment dome on May 6, 2010. On May 7, it was placed

over the BOP stack. The Cofferdam containment dome system and procedure was abandoned the next day after methane hydrates (methane gas incorporated in an ice matrix) formed at the riser opening, made the Cofferdam containment dome buoyant, lifted it off of the well, and made it uncontrollable at the surface, rendering this containment strategy useless.

On May 16, 2010, BP sought to begin capture, flowing subsurface oil by siphoning it from the broken riser pipe. A riser insertion tube tool was designed to recover and collect oil in the Transocean dynamically positioned drillship *Discoverer Enterprise*, which had been deployed to the scene. A tube was inserted into the end of the broken riser lying on the bottom and a rubber diaphragm seated the riser insertion tube tool against the riser walls to form a seal. Nitrogen gas was injected to reduce methane hydrate formation. The riser insertion tube tool system was partially successful. It captured approximately 22,000 bbl of oil, but it never captured the total flow of oil from the riser opening, which at that time was estimated to be ~5,000 bbl/day. Based partly on the results of the riser insertion tube tool system capturing oil, the spill rate was revised to approximately 12,000-19,000 bbl/day (USDOI, 2010a).

On May 25, 2010, the riser insertion tube tool system was abandoned in preparation for a well shut-down procedure called “top kill.” Top kill involved pumping heavy drilling mud under pressure through two 3-in-diameter flowlines into the BOP to force the oil downhole. BP began the “top kill” procedure on May 26 at 1:00 p.m. CDT and followed initiation with the first of two “junk shots,” an operation involving the injection of pieces of rope, shredded rubber, golf balls, and other materials into the flow lines of the BOP in an effort to clog it. Neither the top kill nor the junk shot came close to succeeding because the pressure of oil and gas escaping from the well was greater than the pressure that could be applied by force-injected drilling mud. On May 30, Kaufman and Krauss (2010) quoted a BP source as stating that engineers never had a complete enough understanding of the drill pipe casing configuration or the field modifications that had been made to the BOP mechanism to be confident in success of the procedures. Krauss et al. (2010) recounted that, for the first hours of the first top kill procedure, downhole pressure began to decrease; a sign that the pumped-in drilling mud was succeeding in overcoming the pressure of the oil venting from the reservoir. Shortly thereafter, the pressure readings leveled off, indicating that drilling fluid was leaking into the formation or venting through the BOP. Had the junk shot and top kill worked in combination to equalize the pressure, flowing gas and oil would have been arrested and the well-killing operation would be completed by downhole injection of cement to seal the well. The first top kill attempt was followed shortly by a second on May 28, 2010, but at 1:30 a.m. CDT, BP announced that this procedure had failed to equalize pressure, with oil and gas venting from the wellbore; and the cementing phase was not attempted.

In a June 22, 2010, interview in the *Los Angeles Times* (Tankersley, 2010a), Energy Secretary Steven Chu stated that engineers working to cap the Macondo oil spill should have acted sooner to attempt the top kill method to overpower and seal the well in order to boost its chances for success. Tankersley (2010b) reported that imaging equipment use by DOE detected not one but two drill pipes, side by side, inside the wreckage of the well’s BOP and hypothesized that either the well casing or part of the drill string was explosively forced up the well by the erupting gas bubble, violently telescoping the pipe while slamming it into the bottom of the BOP.

The next containment option was to deploy a system called the lower marine riser package cap containment system, also called “top hat.” On May 12, 2010, the top hat, called “top hat No. 4,” was placed on the seabed near the wellhead while the drillship *Discoverer Enterprise* was constructing and lowering the riser system that would bring captured oil to the surface after failure of the Cofferdam containment dome. On June 3, 2010, an ROV cut off the end of the broken riser pipe at the top of the BOP to leave a cleanly cut pipe. After a 20-hour procedure, the sealing cap was affixed to the top of the riser, and captured oil and gas began to flow through the riser to the *Discoverer Enterprise*. The amount of oil recovered by this system was ~10,000 bbl/day, much more than expected and beyond the capacity of the *Discoverer Enterprise*. The oil that could not be captured was vented through the “top hat” to the ocean. The result of a fitting “top hat” was that downhole pressure from the well could be measured more accurately and as a result the UIC revised the estimate for well flow rate to between 25,000 and 40,000 bbl/day.

By mid-June 2010, a small fleet of vessels had been contracted by BP as part of the spill response and had assembled on the surface. On June 16, BP connected the choke lines that were used to pump mud into the BOP for the “top kill” procedure to a separate riser system connected to the *Helix Q4000* vessel as an addition to the lower marine riser package collection system. A specialized clean-burning flare

system was installed on the *Deepwater Discoverer* to burn a combination of oil and gas at the surface, and the *Helix Q4000* flared gas collected through the choke line system. On June 23, Robbins (2010) reported that an ROV impacted the top hat cap and caused it to dislodge and come off. After eight attempts the cap was re-affixed onto the lower marine riser package, and the system was again capturing oil and gas released from the well. By late June and early July, BP's website was reporting that the "top hat" cap on the lower marine riser package and the *Deepwater Discoverer* and *Helix Q4000* flare systems in combination were collecting or burning over 25,000 bbl/day and about 50 Mcf of gas. The loose-fitting top hat collected most of the oil and operated until July 10, but the system never could accommodate the total flow of oil from the well head, and part of the flow still vented into the ocean during the entire period of its use from June 3 to July 10, 2010. The Department of Energy's (DOE's) spill-response website includes spreadsheets reporting the quantity of oil and gas captured by the riser insertion tube tool, and "top hat' systems (USDOE, 2010). The spill flow rate estimate was revised by the Flow Rate Technical Group to 20,000-40,000 bbl/day by examining the flow plume after the riser pipe was cleanly cut before emplacement of the top hat and lower marine riser package.

Hurricane Alex made landfall at Matamoros, Mexico, on June 30, 2010, and moved inland. The storm raised high seas and winds in the spill area, bringing oil skimming, application of aerial dispersants, and burning operations to a halt until July 5, 2010. The rigs drilling the relief wells remained on station throughout the weather stand down. On July 2, USCG officials began flying over the oil-spill site to assess the damage left by Hurricane Alex, noting dislodged boom along the shoreline.

On June 17, 2010, the Associated Press (2010) reported that BP had committed to deploy 32 centrifugal-based oil separation systems from Ocean Therapy Solutions, a company that was co-founded by Kevin Costner. The first three devices were barged to the spill site for testing. The system, called *Ocean Therapy*, skims and pumps oily water onto barges, where a centrifuge unit separates oil from water that is then returned to the sea. Each device can process approximately 200,000 gallons (4,762 bbl) of oily water per day.

On June 25, 2010, with no assurances it would be contracted by BP or allowed by UIC to join the Gulf of Mexico oil-spill cleanup, a Taiwanese-owned ship billed as the world's largest skimming vessel, *A Whale*, embarked from Norfolk, Virginia, for the Gulf of Mexico. *A Whale* is approximately 1,050 ft (320 m) long and 10 stories high. It is designed to collect up to 500,000 bbl of oily water a day through six intake vents on each side of its bow. Skimmed oily water was designed to be processed and separated, with oil stored in holding tanks and with processed water eventually discharged back to the sea. Approval from USEPA was needed because of the residual oil in discharged water. *A Whale* arrived at the spill site on July 2, 2010, and deployed to a location north of the source to begin ballasting to intake water level for skimming. Testing of the system began on July 6 and a series of modifications were made to adjust system performance until July 16 when the evaluation was ended. On July 17, 2010, *A Whale* departed the area after not performing as expected. Fountain (2010a) reported that the dispersed nature of the spill tended to work against *A Whale's* skimming system, which was designed to intake a more dense and concentrated oil slick.

The National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling released periodic staff working papers on topical issues that were within the Oil Spill Commission's area of investigation. Staff Working Paper 6 (Oil Spill Commission, 2011a) presented a detailed explanation of the 5-month effort to permanently plug the Macondo spill.

Engineered Shoreline Barriers

On May 11, 2010, the State of Louisiana submitted an emergency application to the Corps of Engineers (COE) for the dredging of sand to build a "barrier berm" system to prevent oil from entering coastal marsh lands. The berms were proposed to be emergent structures extending along the length of the Chandeleur Islands and the barrier islands from East Grand Terre Island eastward to Sandy Point. The dimensions are approximately 50 ft (15 m) wide at the base and 20 ft (6 m) wide at the top, built at the toe of existing barrier islands or in tidal inlets between existing islands. Originally, the borrow sources for the berm material were to be a shore-parallel trench dredged approximately 1 mi (1.6 km) offshore of the Chandeleur Islands, Ship Shoal on the OCS, the Mississippi River offshore disposal site, and the Pass a Loutre hopper disposal area. On May 14, 2010, the consulted Federal agencies provided written feedback to COE on the nature of the State's proposed action, and on that same date, the State submitted a revised

plan to COE. This revised plan extended the reach westward to Timbalier Island and removed the nearshore borrow trench along the Chandeleur Islands. The COE requested additional information, and on May 21 and May 24, 2010, that information was provided by the State. On May 27, COE approved elements of the State's proposal, which includes six segments of barriers about 40 mi (64 km) long that included, from the State's application, Segments E3 and E4 (25.8 mi; 41.5 km) along the northern part of the Chandeleur chain east of the Mississippi River and Segments W8, W9, W10, and W11 (14.5 mi; 22.3 km) along the Plaquemines Parish barrier island shoreline west of the Mississippi River. The UIC gave immediate go-ahead on just one of those six segments, i.e., a 2-mi (3-km) barrier berm off Scofield Island (Segment W9) in Plaquemines Parish, where oil was already reported, and using sand from the Pass a Loutre Hopper Dredge Disposal Site. On June 1, 2010, UIC convened a meeting in New Orleans to discuss the State's proposal. The State had proposed that BP be required to pay the estimated $360 million for the barrier berm project as part of the integrated spill response. After a variety of viewpoints were expressed in the June 1 meeting, UIC required BP to pay for only the Scofield Island segment in western Plaquemines Parish.

Federal officials permitted the project after the State agreed to dredge sand to build the berms from a borrow site north of the Chandeleur chain, Hewes Point. From Hewes Point, sand was to be transported by slurry through a submerged pipeline to the berm construction site. On June 2, UIC ordered BP to pay for all 40 mi (64 km) of berm authorized, and on June 13, construction work on the first berm segment began at the Chandeleur Islands. Despite the borrow site agreement, on June 13, 2010, the State asked the Federal Government for permission to dredge sand from a nearshore location positioned over the pre-Katrina footprint of the Chandeleur Islands (south of Hewes Point) and within the boundaries of the Breton National Wildlife Refuge, after apparently having trouble procuring the length of pipeline needed to pump from Hewes Point. The COE and FWS agreed to let the State dredge from this nearshore location for 1 week while waiting on dredge pipe, provided they backfilled the dredge pit immediately. On June 14, the cutterhead dredge *California* arrived and began to set pipe between the dredge at the nearshore borrow site and the berm construction site. Over 10 support vessels, including barges, crew quarters, and ferries, were mobilized at the site. On June 22, the State asked for permission for another 5-10 days of sand borrowing from the nearshore borrow site, promising to eventually replace the sand borrowed. Assistant Secretary of the Interior, Thomas Strickland, rejected Louisiana's request for the additional 10 days to construct 2 mi (3 km) of pipeline and ordered the dredging from the nearshore location to stop while the pipeline was constructed to Hewes Point. On June 30, 2010, COE gave the go-ahead for the State to resume dredging after the additional pipeline was laid to transport sand from the designated borrow site at Hewes Point. The State's contractors did not resume dredging because of inclement weather caused by the passage of Hurricane Alex. In an open letter to UIC released on July 21, 2010, a group of 21 coastal scientists called for a halt to large-scale engineering projects, such as Louisiana's barrier berms and rock armoring, aimed at protecting wetlands from oil from Macondo (Spotts, 2010).

On May 14, 2010, Louisiana's Office of Coastal Protection and Restoration requested a lease from BOEMRE to use Ship Shoal and St. Bernard Shoals sand for the emergency berm construction. A negotiated emergency sand agreement was executed between the Office of Coastal Protection and Restoration and BOEMRE on July 16, 2010, for the use of OCS sand from St Bernard Shoals for construction of the E3 and E4 berm segments along Chandeleur Islands. However, no OCS sand was used during berm construction because of Endangered Species Act issues related to hopper dredging and sea turtle takes, as well as DWH's Federal on-scene coordinator's denial of Louisiana's request for concurrence with planned OCS sand mining activity as part of the spill response.

On August 3, 2010, the UIC Daily Report reported that 1,330,309 yd^3 (1,017,094 m^3) (Hewes Point) were borrowed for Chandeleur Segment E4 and that 134,042 yd^3 (102,483 m^3) were borrowed for Scofield Island Segment W9 (Pass a Loutre borrow site) (U.S. Dept. of Homeland Security, CG, 2010).

In addition to the sand berm project, multiple smaller-scale efforts were initiated by the State in an attempt to block oil from entering estuaries and interior wetlands. Blackhawk and Chinook helicopters manned by the Louisiana National Guard dropped 7,000-lb sandbags one by one into the sea (Muir, 2010). On May 26, 2010, the Governor's office website posted that the National Guard dropped over 1,075 sandbags on Pelican Island, east of Grand Isle, filling five of the eight gaps in the island and that bags were also dropped in the first gap out of six expected to be filled on Scofield Island (State of Louisiana, Office of the Governor, 2010).

With oil reported in Barataria Bay as early as May 2010, local parish officials proposed a plan, supported by the Governor of Louisiana, to build rock dikes across several major tidal inlets between the bay and the Gulf of Mexico to block and then capture the oil. Rudolf (2010a) reported that by early June, about 100,000 tons of rock had been loaded onto barges on the Mississippi River for transport to the coast; however, on July 3, 2010, COE denied a permit for the project, citing concerns that rock barriers could alter tidal flow patterns and cause widespread erosion and breaching of Barataria Bay's existing barrier islands.

On August 5, 2010, Scott (2010) reported that the State's dredging contractors had moved about 5,000,000 yd^3 (3,822,774 m^3) of sediment to construct 4 mi (6.5 km) of berm near Scofield Island (Segments W9 and W10) to create narrow artificial islands to block oil moving into coastal wetlands, at a cost to BP of $120 million. On September 15, the Louisiana Governor's Office of Coastal Activities posted a website update of the State's berm construction activities and reported that an estimated 8.5 mi (13.6 km) of berm had been constructed (State of Louisiana, Office of Coastal Protection and Restoration, 2010).

On October 6, Ball (2010) reported that the State was scaling back their extensive dredging program that had been designed for, and justified as, part of the spill response to contain oil. Rudolf (2010b) reported that the State had significantly altered its original proposal, allowing for large gaps between the berm segments to ease concerns that tidal circulation in estuaries would be adversely affected. The article contained a graphic that showed completed, under construction, and planned berm in the following two focus areas: Scofield Island and the northern Chandeleur Islands.

During a November 10, 2010, multiagency teleconference that included the State, BOEMRE, and COE, the State's emphasis on the berms as an oil-spill-response measure transitioned to an emphasis on the berms as a coastal restoration measure. The State reported the following: (1) their desire to cease berm work by November 30; (2) their desire to use the remainder of berm funding (~$100 million) on new or continued barrier island restoration projects at Shell Island, Pelican Island (CWPPRA Project BA-38), Scofield Island (CWPPRA Project BA-40), and the northern part of the Chandeleur chain; (3) that construction of the western Plaquemines berm Segments W8, W9, and W10 were completed; (4) that dredging at Hewes Point continued; and (5) that the State was requesting to shift the Chandeleur E4 berm footprint landward (Ashworth, written communication, 2010). Berm construction ended in March 2011. A total of approximately 10,300,000 yd^3 of sand was placed to construct 20.5 mi (33 km) of berm, of which 8.8 mi (14.2 km) were constructed along the Segment E-4 along the northern Chandeleur Islands in St. Bernard Parish and 11.7 mi (18.8 km) were constructed along Segments W-8, W-9, and W-10 in Plaquemines Parish. All sand used to construct the berm was mined from Hewes Point north of the Chandeleur Islands (Louisiana State waters) and from the lower Mississippi River.

The National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling has periodically released staff working papers on topical issues the Commission dealt with. On December 16, Staff Working Paper 8 was posted to the Commission's website (Oil Spill Commission, 2011b). It contains a more detailed summary of the Louisiana sand berms project. The working paper concludes that, "From a long-term coastal restoration perspective, the berms may indeed be a significant step forward," as Governor Jindal has claimed, but they were not successful for oil-spill response" (Oil Spill Commission, 2011b, p. 39).

The Louisiana Governor's Office of Coastal Activities reported that at least 1,000 bbl of oil were captured by the berms (Oil Spill Commission, 2011b, p. 37). The staff working paper details the pressure exerted by Governor Jindal and Parish leaders to approve and expedite the berm projects, how President Obama acceded to the State's sense of urgency, and how National Incident Commander Thad Allen's approval for the State's May 27 request for the initial 40 mi (64 km) of berms was a "borderline call." Power (2010) reported on December 17 that the pleas of Louisiana's politicians "overwhelmed" the Government's scientific analysis. In a USGS evaluation of the effects of the barrier berms, Lavoie et al. (2010, p. 6) recommended long term monitoring for the berms completed and emphasized that although sand berms are intended to be sacrificial, the sand used to build them will be redistributed as berms erode and that berms should not be confused with and will not have the longevity of a barrier-island restoration.

As of December 8, 2010, COE had not received permit applications from the State for any of the newly identified restoration projects (Ashworth, written communication, 2010). The only project with the potential to use OCS sand would be the Pelican Island project, which identifies the Empire and Sandy Point borrow sites in West Delta leasing area as an alternative.

Permanently Plugging the Macondo Well

To resolve the spill, a tightly fitting "capping stack" was needed on the BOP; but first, what was left of the severed riser pipe had to be removed from the top of the BOP. On July 10, 2010, the "top hat No. 4" system was removed to replace it with a better-fitting cap consisting of a flange transition spool and a 3-ram stack, known informally as "top hat No. 10." Krauss et al. (2010) reported that the procedure involved loosening five large bolts to remove the broken riser pipe and to provide a clean connection between it and the capping stack, which could be bolted down to withstand reservoir pressure. At 12:00 p.m. CDT on July 15, oil and gas recovery activity stopped and an "integrity test" of well pressure was carried out by slowly closing the valves on the stack. Pressure in the wellbore rose and choked off the flow on July 15—after 87 days. On that day, separate press conferences were held by BP and UIC to announce that the Macondo well had been "shut in."

On July 19, Fountain (2010b) reported that the recently capped well was maintaining pressure and that BP hoped to keep the well shut in until it could be permanently plugged with the "bottom kill" technique with one or both relief wells. By July 7, the *Development Driller III* had drilled the first relief well to a depth of 12,780 ft (3,895 m) below mudline, and the *Development Driller II* had drilled the second relief well to a depth of approximately 8,900 ft (2,713 m) below mudline. Since shutting in the well, BP continued the "ranging" process, i.e., periodically withdrawing the drill pipe and sending an electrical signal down to determine how close they were getting to the metal casing string in the Macondo well.

Between July 20 and 25, 2010, all UIC spill operations were shut down because of Tropical Storm Bonnie. Reconnaissance after Bonnie showed that, out of the 508 mi (817 km) of boom in the Louisiana area, 95 mi (153 km) of boom was displaced (18%), 32 mi (51 km) of boom was stranded on the beach (6%), and 381 mi (613 km) of boom remained set in place (75%).

On August 3, a "static kill" procedure was initiated; this procedure involved equalizing pressure from the reservoir with mud pumped downhole through the wellhead. Over a period of 8 hours, drilling mud was slowly pumped into the well at ~2 bbl per minute until a static condition was achieved. On August 4, BP began pumping cement from the top, permanently sealing the upper part of the casing string. On September 3, 2010, the 300-ton failed BOP was removed from the wellhead and was lifted slowly to the surface. Later that day, a replacement BOP was affixed to the wellhead. On September 4, the failed BOP reached the surface and was placed in a special container on board the vessel *Helix Q4000* and sealed as evidence by the Department of Justice for the spill investigation. The failed BOP was taken to NASA's Michoud Facility in New Orleans, Louisiana, for forensic examination.

Drilling of the first relief well by *Development Driller III* was halted in early August while the static kill procedure was carried out. Bad weather and concerns about how an increase in pressure inside the well during the bottom kill would affect the well structure and stability delayed drilling for 6 weeks. Drilling on the first relief well resumed on September 13, 2010. At that time, the drill bit was spatially located about 3.5 ft (1 m) horizontally and 50 ft (15 m) vertically from the intersection point with the damaged well casing, a target size reported to be 8-10 in (20-25 cm) in size. Television reports commonly used a dinner plate as a handy reference for the target size. Engineers drilled about 30 ft (9 m) initially, retracted the drill pipe, and then inserted another tool to conduct a "ranging" exercise to make sure the well was in the right position to penetrate the wellbore.

Fountain (2010c) that the wellbore was intersected on September 17, allowing the "bottom kill" operation to begin; however, before penetrating the casing, engineers first determined the nature of the well-bottom environment. Tests showed there was no cement or oil in the annulus at the intersection point. The casing was then penetrated with a special tool called a mill, after which about 100 bbl of cement was used in the bottom kill to seal the annulus area and what remained of the open hole in the casing bore itself after the static kill operation on August 3 had filled most of it. On September 19, 2001, after allowing time for the cement to cure, crew aboard the *Development Driller III* conducted a pressure test on the integrity of the seal for the cement that had been pumped into the Macondo well. On September 19, at 5:54 a.m. CDT, the test confirmed that the cement formed an effective and final seal for the well. On September 19 at 10:37 a.m. CDT, National Incident Commander Thad Allen declared the well dead (RestoreTheGulf.gov, 2010a) and that responsibility and oversight for the well would pass from the National Incident Commander to BOEMRE.

Amount of Oil Spilled

The rate at which oil was spilling from the Macondo well was a point of intense controversy from the very beginning because no flow meter at the wellhead could directly account for it. The Oil Spill Commission's Working Paper 3 (2011c) summarized the Government's published estimates:

(1) April 24, 2010—1,000 bbl/day (p. 3);

(2) April 28, 2010—5,000 bbl/day (p. 3);

(3) May 27, 2010—12,000-19,000 bbl/day (p. 14);

(4) June 3, 2010—20,000-40,000 bbl/day (p. 14);

(5) June 10, 2010—25,000-40,000 bbl/day (p. 15);

(6) June 15, 2010—35,000-60,000 bbl/day (p. 16); and

(7) August 2, 2010—52,700-62,200 bbl/day (p.17)

Estimates that are Government or UIC sanctioned represent a trend of ever-increasing flow rate estimates with the final flow rate estimate based on direct pressure measurement. After BP and the USCG estimated 1,000 bbl/day on April 24, 2010, and NOAA estimated 5,000 bbl/day, on May 19, the UIC assembled a number of interagency expert scientific teams of government and nongovernment specialists to estimate the quantity of oil that had been released from the well and ultimately the fate of that oil. A Flow Rate Technical Group, led by Secretary of Energy Steven Chu and USGS Director Marcia McNutt, was assembled by UIC in May 2010 to calculate the flow rate and to estimate the total volume of oil released. On May 27, the Flow Rate Technical Group reported their first estimated flow rate of 12,000-19,000 bbl/day based on the following three separate methodologies: (1) mass balance for visible and infrared imaged surface oil; (2) plume modeling of oil and gas escaping from the marine riser before the riser insertion tube tool; and (3) with 1 and 2 checked by a minimum flow rate based on the riser insertion tube tool and from oil escaping the tool and from the top of the kinked riser pipe. After the riser pipe was cut on June 3, visual examination of the flow plume through one opening allowed the Flow Rate Technical Group to revise upward the estimated daily flow rate to 20,000-40,000 bbl/day. After examining direct pressure measurements of the flow in the top hat system, on June 15, the Flow Rate Technical Group revised upward the estimated daily flow rate to 35,000-60,000 bbl/day. A final estimate of 52,770-62,200 bbl/day was made on August 2, just prior to release of the Oil Budget Calculator on August 4 (Lubchenco et al., 2010).

After the well was capped on August 2, 2010, the Flow Rate Technical Group announced that an estimated 4.9 million bbl of oil had been released by the Macondo spill. A second interagency team, led by DOI and NOAA, developed a tool called the Oil Budget Calculator to determine the short term fate of spilled oil. The Calculator used the 4.93 million bbl estimate as its input and used direct measurements and the best scientific estimates then available to determine the fate of the oil (Lubchenco et al., 2010).

On August 4, 2010, Lubchenco et al. (2010) reported that an estimated 25 percent of total spilled oil was removed by burning, skimming, and direct recovery from the wellhead; 25 percent of the total oil had naturally evaporated or dissolved; and just less than 25 percent was dispersed naturally or as a result of the use of dispersant chemicals. The residual amount—just over one-quarter (26%)—was reported to be either on or just below the surface as light sheen. Weathered tar balls in the water column are in the process of being degraded, have been washed ashore or have been collected from the shore, or is buried in sand and sediments. Lubchenco et al. (2010) did not provide the mathematical basis for how the oil was partitioned. That is, the tool was described, but not explained so as to be independently verifiable. Lubchenco et al. reported that estimates would continue to be revised based on new information and for the Natural Resource Damage Assessment (NRDA) being prepared by NOAA.

The first peer-reviewed study of oil quantity from the Macondo spill was released on September 23, 2010, by researchers at Columbia University. The Earth Institute (Nerenberg, 2010) is now referring to the DWH event as "the largest marine oil accident ever." They found that 56,000-68,000 bbl/day were released between April and July, a total equaling 4.4 million bbl of oil, slightly less than the official Government estimate of 4.9 million bbl made to date.

On November 23, 2010, the Oil Budget Calculator, the results from which were first released in August 4, 2010 by Lubchenco et al. (2010), was subjected to further peer review at the request of the National Incident Commander. The report (Federal Interagency Solutions Group, 2010) was prepared by a team of 15 international academic institutions, government agencies, industry experts, and others who called themselves the Federal Interagency Solutions Group. The report documents for the scientific community and other interested parties the technical underpinnings of the Calculator and provides recommendations for future research and refinement of the tool for possible use in future spills.

The Federal Interagency Solutions Group (2010) developed an extensive review of the initial findings and revised, as necessary, the estimated short-term fate of the oil discharged from the Macondo wellhead through July 15, the date the well was capped. The Oil Budget Calculator's purpose was to describe the short-term fate of the oil and to guide immediate efforts to respond to the emergency, guide operational response decisions, and provide clarity on how much oil could be captured or mitigated and how much oil was not recoverable (RestoreTheGulf.gov, 2010b). The Calculator was not intended to provide information about the impacts of the oil or indicate where the oil may now be. The Oil Budget Calculator used collected or reported data, such as the amount captured at the wellhead, combined with model-projected estimates based on historical oil-spill data for similar types of oil, as well as the expertise of the Federal Interagency Solutions Group's participants.

Improvements were made to the Calculator since it was first used in August 2010. The revised Oil Budget Calculator was adjusted based on modified calculations and modeling, as well as additional knowledge about the Macondo spill provided by the science team. The revised calculations provide the basis for the updated budget issued in the report, as well as the best- and worst-case scenarios. The Federal Interagency Solutions Group's (2010) report is largely consistent with early results released by the first interagency estimate (Lubchenco et al., 2010). The most significant change is a doubling of the expected amount of oil classified as "chemically dispersed"—revised from 8 percent to an estimated 16 percent, with a possible range of between 10 and 29 percent. Additional data and studies during the past months have led the Federal Interagency Solutions Group to relax certain initial conservative assumptions with regard to the effectiveness of dispersant operations. The early estimate of the percentage of "other" (or "residual") oil was 26 percent; the current version of the Calculator estimate is 23 percent and qualifies this estimate with the belief that, with high confidence, the true percentage should be between 11 and 30 percent. A comparison between the two iterations of the Oil Budget Calculator is below.

Oil Budget Calculator—August 4, 2010

Category	Percent of Total
Direct recovery	17
Burned	5
Skimmed	3
Chemically dispersed	8
Naturally dispersed	16
Evaporated or dissolved	25
Other	26

Source: Lubchenco et al., 2010.

Oil Budget Calculator—November 23, 2010

Category	Percent of Total	Percent Change from August 4
Direct recovery	17	None
Burned	5	None
Skimmed	3	None
Chemically dispersed	16	+8
Naturally dispersed	13	-3
Evaporated or dissolved	23	-2
Other	23	-3

Source: Federal Interagency Solutions Group, 2010.

The report specifically recommends future research and planning to be directed to three areas that would reduce the uncertainty of the estimates and that would improve future response activities.

First, develop protocols for surface and subsurface sampling. Although oil samples were collected for impact assessment, samples were not systematically collected to support the development of the Oil Budget Calculator. For example, samples often came from skimming barges where oil and water mixtures in different states of degradation were blended together. Future response plans should specify methods for gathering proper representative samples.

Second, develop tools for dispersed oil droplet size characterization. A major improvement in estimating dispersant efficiency would be possible if practical operational tools and methods existed to characterize droplet size distribution of subsurface oil.

Third, develop basic models for longer-term processes. Although longer-term processes such as biodegradation often happen outside the timeframes of the response, understanding and being able to predict such longer-term changes may be useful in making response decisions.

Cause of the Explosion and Spill

The official record of legal causation and responsibility for the DWH event has yet to be written. Legal proceedings to affix responsibility and damages for the spill will proceed for years. The outputs for all of the official inquiries initiated after the Macondo spill are summarized below.

On September 5, Hammer (2010a) reported a sequential summary of the five key human errors and the culminating mechanical failure of the BOP that combined to cause the DWH event. The graph was prepared on the basis of the following: more than 100 hours of testimony since May 11 before the joint investigative panel meeting chaired by USCG and this Agency that convened in Kenner, Louisiana two dozen Congressional hearings; and several internal company reports. Hammer (2010a) reported that there was no single fatal mistake causing the spill; rather, it was a scenario of events that led to the spill that proceeded sequentially:

(1) there were fewer barriers to gas flow because of the well casing design, the so-called “long string” configuration;

(2) there were fewer than customary casing centralizers to keep cement distribution even;

(3) there was no bond log run to test cement integrity;

(4) a key pressure test was misinterpreted;

(5) the drilling mud barrier was removed too early; and

(6) the BOP failed.

On January 6, 2011, the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling posted an advanced chapter (Chapter 4) on their website one week before release of their final report (Oil Spill Commission, 2011d). The immediate cause of the DWH event was a failure to contain hydrocarbon pressures in the well. The following three barriers could have contained well pressures: the cement at the bottom of the well; the mud in the wellbore and in the riser; and the blowout preventer. However, mistakes and failures to appreciate the risk involved compromised each of these barriers, steadily depriving the rig crew of safeguards until the blowout was inevitable and, at the very end, uncontrollable. The Commission concluded in Chapter 4 (Oil Spill Commission, 2011d, p. 115), “that the mistakes and oversights at Macondo cumulatively overwhelmed the safeguards meant to prevent just such a loss in well control from happening can be traced back to a single overarching failure—a failure of management. Better management by BP, Halliburton, and Transocean would almost certainly have prevented the blowout by improving the ability of individuals involved to identify the risks they faced, and to properly evaluate, communicate, and address them.” Among the key findings from Chapter 4 include the following:

- The Macondo blowout was the product of several individual missteps and oversights by BP, Halliburton, and Transocean, which Government regulators lacked the authority, the necessary resources, and the technical expertise to prevent;

- The blowout was not the product of a series of aberrational decisions made by rogue industry or Government officials that could not have been anticipated or expected to occur again. Rather, the root causes are systemic and, absent significant reform in both industry practices and Government policies, might well recur; and
- Each of the mistakes made on the rig and onshore by industry and Government increased the risk of a well blowout, the cumulative risk that resulted from these decisions and actions was both unreasonably large and avoidable, and the risk of a catastrophic blowout was ultimately realized on April 20; several of the mistakes were contributing causes of the blowout.

Chapter 4 (Oil Spill Commission, 2011d, Table 4.10) showed a matrix of decisions that increased the risk at the Macondo well, while potentially saving time and money. Among the examples of engineering mistakes and management failures highlighted in the chapter are given below:

(1) inadequate risk evaluation and management of late-stage, well design decisions;

(2) a flawed design for the cement slurry used to seal the bottom of the well, which was developed without adequate engineering review or operator supervision;

(3) a "negative pressure test," conducted to evaluate the cement seal at the bottom of the well, identified problems but was incorrectly judged a success because of insufficiently rigorous test procedures and inadequate training of key personnel;

(4) flawed procedures for securing the well that called for unnecessarily removing drilling mud from the wellbore. (If left in place, that drilling mud would have helped prevent hydrocarbons from entering the well and causing the blowout.);

(5) apparent inattention to key initial signals of the impending blowout; and

(6) an ineffective response to the blowout once it began, including but not limited to, a failure of the rig's blowout preventer to close off the well.

None of the Oil Spill Commission's findings are in conflict with the September 5, 2010, account by Hammer (2010a). The Oil Spill Commission's account, however, provides technical detail with explanations written for general public. It includes insight informed by the experts from whom the Oil Spill Commission received testimony and criticism in hindsight for the decisions taken by everyone involved in the process—from BP as operator, Transocean as the rig and crew contractor, and Halliburton as the cement contractor.

On September 8, 2010, BP completed and released the company's interpretation of the event scenario in the report titled "*Deepwater Horizon* Accident Investigation Report" (BP, 2010a).

Blowout Preventer Failure Scenario

As explained in the Oil Spill Commission's report, Chapter 4 (2011d, p. 93), the *Deepwater Horizon*'s BOP had multiple rams and preventers designed to seal the well. From top to bottom, Macondo's 400-ton BOP was configured with the following: topmost were two large, donut-shaped, rubber annular preventers to seal off the annular space around the drill pipe; next were five sets of metal rams—the first was the blind shear ram that was designed to cut through drill pipe inside the BOP to seal off the well in an emergency situation and that could be activated manually by drillers on the rig, by an ROV, or by an automated emergency "deadman" system; next was a casing shear ram that was designed to cut through thicker tubulars such as casing in order to seal off the well; and at the bottom were three sets of pipe rams to close off the space around the drill pipe.

The Oil Spill Commission (2011d, pp. 114-115) reported that, minutes before the first explosion on the *Deepwater Horizon* (April 20, 2010, ~9:49 p.m. CDT), the drilling rig crew activated one of the annular preventers; however, flow rates at this point in the loss of well-control event may have been too high for the annular preventer to prevent a blowout. After the first explosion, crewmembers on the bridge attempted to engage the rig's emergency disconnect system, which should have closed the blind shear

ram, severed the drill pipe, sealed the well, and disconnected the rig from the BOP; however, none of that happened. Although the emergency disconnect system panel indicators lit up, the rig never disconnected. It is possible that the first explosion had already damaged the cables to the BOP, preventing the disconnect sequence from starting.

The BOP's automatic mode function (the "deadman" system) should have triggered the blind shear ram after the power, communication, and hydraulics connections between the rig and the BOP were cut; however, the deadman system failed too. Although Chapter 4 of the Oil Spill Commission's report (2011d, p. 115) stated it was too early to tell, the deadman system failure may have been the result of poor maintenance. Post-incident testing of the two redundant "pods" controlling the deadman system revealed low battery charge in one pod and defective solenoid valves in the other. If those problems existed at the time of the blowout, they would have prevented the deadman system from working.

Official Inquiries and Suspensions on OCS Oil and Gas Operations

In the aftermath of the DWH event, four independent reviews, outside of BOEMRE, were carried out on OCS oil and gas operations. The BOEMRE undertook a joint investigation with USCG.

- On April 30 2010, the President directed Secretary Salazar to conduct a thorough review of the DWH event and to report, within 30 days, on what, if any, additional precautions and technologies should be required to improve the safety of oil and gas exploration and production operations on the OCS. The *Increased Safety Measures for Energy Development on the Outer Continental Shelf*, the so-called "30-day Report" or "Safety Measures Report," was delivered on May 27 (USDOI, 2010b) and included a recommendation of a program of immediate recertification of BOP's.
- On April 30 2010, Secretary Salazar asked for the creation of an OCS Safety Oversight Board to provide recommendations for improving and strengthening the Department's overall management, regulation, and oversight of OCS operations, including undertaking further audits or reviews, and reviewing existing authorities and procedures. The Board completed its report on September 1 (USDOI, 2010c) and Director Bromwich made it publically available, with an implementation plan in a press release on September 8, 2010.
- On May 11 2010, Secretary Salazar asked for an independent study by the National Academy of Engineering to analyze root causes of the DWH event and to provide recommendations (USDOI, 2010d). As part of his announcement Secretary Salazar undertook several initiatives: (1) ordered immediate inspections of all deepwater operations; (2) announced a joint investigation of the DWH event with USCG; (3) announced that no permits to drill would be processed until DOI completed the "30-day Report"; and (4) established the OCS Safety Oversight Board within DOI, consisting of the Assistant Secretary Lands and Mineral Management, Assistant Secretary Policy, Management, and Budget, and the Office of the Inspector General. The Academy released its final report on November 16, 2010 (National Academy of Engineers, 2010).
- On May 11, 2010, this Agency and the USCG began a joint investigation into the causes of the DWH event that was convened at the Crown Plaza Hotel in Kenner, Louisiana. As of February 2011 this investigation was not completed.
- On May 14 2010, Secretary Salazar requested that the Office of the Inspector General (OIG) expand on an OIG inquiry and report that found several ethics violations by employees at this Agency's District Office in Lake Charles, Louisiana, to include an investigation into any deficiencies in this Agency's policies and practices that may have contributed to the DWH event. The OIG released its final report on December 7, 2010 (USDOI, OIG, 2010).

- On May 21 2010, President Obama created the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling. The Commission began work on July 12 and their final report was posted on the Commission's website January 11, 2011 (Oil Spill Commission, 2011a).

On May 6, 2010, this Agency announced a deepwater drilling moratorium to last through the month, but which was eventually extended 6 months to November 30. The moratorium affected exploration activity in water depths greater than 500 ft (152 m), which at that time affected 33 exploration or workover well projects. On June 2, Governor Jindal wrote to Secretary Salazar and the President claiming that a 6-month moratorium risked losing more than 20,000 existing and potential new Louisiana jobs over the next 12-18 months (Jindal, 2010). By September 14, *The Times-Picayune* reported that only 160 deepwater rig workers applied for aid from $100-million fund BP set aside on June 16 as part of the $20-billion escrow fund to cover economic damages related to the DWH event (Hammer, 2010b). A September 16 study by an interagency group lead by DOC (USDOC, 2010, p. 15) concluded that roughly 2,000 of the 9,700 workers aboard the more than 3 dozen offshore rigs affected by the moratorium had lost their jobs or moved away from the Gulf since the moratorium was imposed in late May and that another 8,000-12,000 workers (USDOC, 2010, p. 7) in related industries also lost work because of the moratorium. **Figure 3-7** reports the drilling activity levels in the Gulf of Mexico in the months after the DWH event

On May 11, 2010, a joint investigation by USCG and this Agency began to identify the factors leading to the DWH event began meeting in Kenner, Louisiana. David Dykes of this Agency and Capt. Hung Nguyen of USCG were co-chairs of the investigation. The USCG and this Agency shared jurisdiction for the investigation because the casualties aboard the *Deepwater Horizon* took place on the OCS. Upon completion, the investigation will issue a single report to the DOI Secretary and the Coast Guard Commandant. A projected completion date for the report is not available.

On May 19, 2010, DOI Secretary Salazar announced (USDOI, 2010e) that this Agency would be renamed and reorganized as the Bureau of Ocean Energy Management, Regulation and Enforcement.

On May 28, 2010, the Secretary directed this Agency to exercise its authority under the OCSLA to suspend certain drilling activities in water depths of 500 ft (152 m) and deeper for a period of up to 6 months. The May 28th suspension was intended to provide sufficient time to (1) ensure that drilling operations similar to conditions that apply to the DWH event operate in a safe manner when drilling resumes, (2) account for the expected timeline for killing the Macondo well so that the extensive spill response resources directed toward the spill would start to become available for other spill events, and (3) provide adequate time to obtain input from ongoing investigations of the accident and to develop and promulgate regulations that address issues described in the Safety Measures Report.

On June 22, 2010, the United States Federal District Court in the Eastern District of Louisiana enjoined enforcement of the May 28th suspension. On July 12, 2010, the Secretary issued a decision memorandum rescinding the May 28th suspension and imposing a second suspension of certain drilling operations in deep water; this suspension was effective until November 30, 2010. In particular, the July 12th suspension applied, with certain exceptions, to the drilling of wells using a subsea BOP or a surface BOP on a floating facility. Three primary issues supported this temporary pause in drilling operations. The suspension (1) allowed time for BOEMRE to implement appropriate workplace and drilling safety measures; (2) was intended to provide BOEMRE, the industry, and others time to develop strategies and methods of containment of wild wells in deep water; and (3) was necessary to ensure that appropriate and sufficient response resources would be available in the event of another major oil spill.

The BOEMRE reduced the duration of the July 12, 2010, suspension insofar as it applies to deepwater development drilling operations and wrote an environmental assessment with a Finding of No Significant Impact (USDOI, BOEMRE, 2010a). The Secretary of the Interior thereafter directed that the July 12 suspension on the drilling of deepwater development wells be lifted as of October 12, 2010. Deepwater drilling is defined as drilling operations using a subsea BOP or a surface BOP on a floating facility. After October 12, 2010, BOEMRE began to review and approve pending and future applications for permits to drill deepwater development wells using a subsea BOP or a surface BOP on a floating facility.

The BOEMRE has addressed, through multiple strategies, the three issues posed as necessary prerequisites to terminating the July 12, 2010, activity suspension early. The BOEMRE has collected a

large amount of information through public hearings and other meetings held specifically on the DWH event and through public comments on rulemaking efforts. The information collection, review, and analysis efforts resulted in new regulations and planned Notices to Lessees and Operators (NTL's) and BOEMRE procedures that address drilling safety, oil-spill response, and enhanced inspection procedures. These regulations, NTL's, and procedures were not in effect at the time of the DWH event, but they will apply to all future applicable drilling activities. The regulations, NTL's, and procedures include the following:

- NTL 2010-N05, "Increased Safety Measures for Energy Development," effective June 8, 2010 ("Safety NTL").
- NTL 2010-N06, "Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS," effective June 18, 2010 ("Plans NTL").
- NTL 2010-N10, "Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources," effective November 8, 2010 ("Certification NTL").
- The Drilling Safety Rule, Interim Final Rule to Enhance Safety Measures for Energy Development on the Outer Continental Shelf ("Drilling Safety Rule"). This rule strengthens requirements for safety equipment, well control systems, and blowout prevention practices on offshore oil and gas operations.
- The Workplace Safety Rule on Safety and Environmental Management Systems ("SEMS Rule"). This rule requires operators to develop and implement a comprehensive SEMS for identifying, addressing, and managing operational safety hazards and impacts; promoting both human safety and environmental protection; and improving workplace safety by reducing the risk of human error.
- Enhanced Inspection Procedures. The BOEMRE is developing plans and schedules for conducting safety inspections of all deepwater drilling facilities. These plans and schedules will be implemented upon the recommencement of deepwater drilling operations.

On February 28 2011, BOEMRE approved the first deepwater drilling permit since the *Deepwater Horizon* explosion and resulting oil spill. The BOEMRE has worked diligently to help industry adapt and conform to new and rigorous safety practices. The permittee provided adequate information to demonstrate that the proposed action met new safety regulations and information requirements in NTL 2010-N06, NTL 2010-N10, and the Interim Final Safety Rule. This permit added to the increasing number of permits that have been approved since new safety regulations have been put in place, including 37 permits for new shallow-water wells.

Spill Inquiries and Immediate Aftermath

On June 16, 2010, as part of a speech to the Nation, President Obama announced that Secretary of the Navy Ray Mabus, a former Mississippi governor, was to prepare a long-term recovery plan for the Gulf Coast in the aftermath of the DWH event. After extensive travel and many meetings, Mabus's report, *America's Gulf Coast: A Long-Term Recovery Plan after the Deepwater Horizon Oil Spill*, (RestoreTheGulf.gov, 2010c) was released on September 28, 2010. The plan recommended that Congress dedicate a significant amount of any civil penalties obtained from parties responsible for the DWH event into a Gulf Coast Recovery Fund to go toward addressing long-term recovery and restoration efforts in the Gulf. To manage the funds and to coordinate recovery projects, the Mabus report recommends that Congress authorize a Gulf Coast Recovery Council that includes representatives from the states and federally recognized Gulf tribes. The Recovery Council would work to ensure that local governments and citizen stakeholders also play a critical role.

The September 28 press release accompanying the plan forecasted that the President would sign, and on October 5 did sign, an Executive Order (The White House, 2010) to establish the Gulf Coast Ecosystem Restoration Task Force (**Chapter 3.3.4**). A bridge to the Gulf Coast Recovery Council, this intergovernmental advisory body consists of 12 executive office agencies and groups, with provisions for State and tribal participation. The Gulf Coast Ecosystem Restoration Task Force would coordinate restoration programs and projects in the Gulf region, focus on efforts to create more resilient and healthy Gulf Coast ecosystems, and encourage support for economic recovery. The President named USEPA Administrator Lisa Jackson to serve as presiding officer of the Gulf Coast Ecosystem Restoration Task Force.

Effective as of October 12, 2010, Secretary of the Interior Secretary Ken Salazar directed that the July 12 suspension of operations for deepwater oil and gas drilling could be lifted, provided that operators certify compliance with all existing rules and requirements, including those that recently went into effect (**Chapter 1.3.1**), and demonstrate the availability of adequate blowout containment resources. In the July 12 Decision Memorandum imposing the suspension for deepwater operators that deploy a subsurface BOP or a floating MODU with a BOP on the rig floor, the Secretary requested BOEMRE to report its findings and recommendations as to whether or not modifications to the scope or duration of the deepwater drilling suspension would be appropriate.

Director Bromwich prepared his October 1 report (Bromwich, 2010) and recommendations based on extensive public outreach and information gathering, including the eight public forums he held around the country to assess safety, spill response, and blowout containment issues. Secretary Salazar reached his decision after reviewing BOEMRE's Director Bromwich's report (Bromwich, 2010) and after considering other information on the progress of offshore oil and gas safety reforms, the availability of spill-response resources, and improved blowout containment capabilities. The BOEMRE announced its intention to conduct inspections of each deepwater drilling operation for compliance with regulations, including, but not limited to, the testing of BOP's before an individual deepwater drilling operation is resumed.

On November 16, 2010, the National Academy of Engineers released a preliminary report on the DWH event (National Academy of Engineers, 2010) and forecast a final report in June 2011. Some of the panel's findings are as follows: (1) it was a critical mistake not to shut down the well despite warnings that the cement job had failed, suggesting an insufficient consideration of risk; (2) too many procedures were being run simultaneously; (3) there are questions about the adequacy of operating knowledge on the part of key personnel; and (4) many decisions were less expensive and time consuming than other options. Other issues highlighted in the report were concern among DWH crew members about who was in charge, important members of the rig crew suffered from insufficient training, and this Agency had failed to put in place the oversight systems that could have helped prevent such an event and lacked important in-house expertise and technical capabilities.

On December 7, 2010, the DOI's Office of the Inspector General released the inquiry requested by Secretary Salazar on May 25 (USDOI, OIG, 2010). The OIG's charter was to investigate performance of BOEMRE's regulatory functions, policies, or practices to see if deficiencies needed to be addressed to ensure that OCS operations are conducted in a safe manner that is protective of human life, health, and the environment. Because the OIG investigation and the OCS Safety Oversight Board were asked to perform somewhat similar investigations, the OIG and Safety Board performed this investigation as a team in the early stages, with the Safety Board issuing its report with the most pressing finding on September 1, 2010 (USDOI, 2010c). The OIG conducted site visits and interviewed BOEMRE staff and management about inspections, permitting, environmental and cultural resource protection, and safety programs. The OIG also conducted two online surveys targeting the BOEMRE staff involved in inspections and environmental and cultural resources, respectively. The OIG reported both their of the surveys and raw survey outputs (USDOI, OIG, 2010) and the OIG's independent view and analysis of many of the same issues advanced by the Board. The OIG's report contains 64 recommendations, 55 of which were also contained in the OCS Safety Oversight Board's September 1 report (USDOI, 2010c). The OIG did not raise substantive new issues; rather, it expounded upon those issues identified in summary fashion in the Safety Oversight Board report, and the OIG recognized that many of the recommendations contained in its report were already being addressed by BOEMRE.

The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling called for by President Obama on May 21, 2010, was chaired by Fran Ulmer, Chancellor of the University of Alaska Anchorage. He and six members brought a broad spectrum of expertise to the work of the Commission

that included expertise in engineering, oil industry, environmental science, and law. Subject areas considered included spill response, restoration, regulatory oversight, corporate culture, safety, and the Arctic. Since the first meeting in July, the Oil Spill Commission has held multiple site visits in all the Gulf Coast States. In public meetings in New Orleans, Louisiana, and Washington, DC, comments were collected from community members, small business owners, and State and local officials, and testimony was taken from industry and government representatives who also provided extensive background information and papers describing the factors that contributed to the DWH event.

On January 11, 2011, the Oil Spill Commission released their full report (Oil Spill Commission, 2011d). It presents the Commission's complete examination of the causes of the DWH event, the Macondo spill response, and consequences of the spill based on the witness record and documentation reviewed by the Commission. In a separate summary for decisionmakers, it includes recommendations for Congress, the Executive Branch, DOI, and industry (Oil Spill Commission, 2011e). Recommendations are grouped in nine distinct categories:

(1) Improving the Safety of Offshore Operations: Government's Role;

(2) Improving the Safety of Offshore Operations: Industry's Role;

(3) Safeguarding the Environment;

(4) Strengthening Oil-Spill Response, Planning, and Capacity;

(5) Advancing Well-Containment Capabilities;

(6) Overcoming the Impacts of the *Deepwater Horizon* Spill and Restoring the Gulf;

(7) Ensuring Financial Responsibility;

(8) Promoting Congressional Engagement to Ensure Responsible Offshore Drilling; and

(9) Moving to Frontier Regions.

Six of the nine recommendations pertain to issues of governance, national policy, the OCS Program, and regulatory philosophy that are beyond the scope of this Supplemental EIS. Three recommendations that are applicable to OCS leasing and operations, oil-spill response, and well control are addressed here.

Recommendations under Category 3 (Oil Spill Commission, 2011e, p. 18), "Safeguarding the Environment," are within the scope of this Supplemental EIS or the National Environmental Policy Act (NEPA) process as implemented by BOEMRE. The Commission reported that the adequacy of the existing regulatory regime to assure the environmental safety of offshore drilling (as distinct from worker or occupational safety) had come under a great deal of scrutiny since the *Deepwater Horizon* event. The Commission focused on two issues: (1) the application of NEPA requirements to the offshore leasing process; and (2) the need for better science and greater interagency consultation to improve decisionmaking concerning the management of offshore resources.

The Oil Spill Commission recommended a need to revise and strengthen NEPA policies and practices in the offshore drilling context and for greater interagency consultation (Oil Spill Commission, 2011e, pp. 18-22). The Commission offered observations on BOEMRE's implementation of NEPA, which included the following:

(1) the manner in which this Agency applied the concept of "tiering" was not always consistent with its original purpose and that this Agency created a system where deeper environmental analysis at more geographically targeted and advanced planning stages did not always take place;

(2) the use of NEPA's "categorical exclusions" was inconsistent among this Agency's regional offices and that how categorical exclusions were applied to major drilling and development projects were clearly shown, post-Macondo spill, to not be the type of activity NEPA envisioned for these exclusions ("activities involving limited environmental risk");

(3) the lack of a NEPA requirements and implementation handbook for use within this Agency was regarded as a critical oversight; and

(4) smaller OCS areas should be offered for leasing, especially in frontier areas, which could receive more detailed attention during a NEPA review.

Following on these observations, the Oil Spill Commission's (2011e, pp. 18-22) more particular recommendations included the following:

(1) the Council on Environmental Quality and DOI should revise and strengthen NEPA policies, practices, and procedures to improve the level of environmental analysis, transparency, and consistency at all stages of the OCS planning, leasing, exploration, and development process; and

(2) the DOI should reduce the risk to the environment from OCS oil and gas activities by strengthening science and interagency consultations in the OCS oil and gas decisionmaking process, and improvements to interagency cooperation should be supported by industry fees.

Recommendations under Category 4 (Oil Spill Commission, 2011e, pp. 26-33), "Strengthening Oil Spill Response, Planning, and Capacity," included those that responded to a need for a new approach to handling spills of national significance, a need to strengthen State and local involvement, a justification for increased research and development to improve spill response, a need for new regulations to govern the use of dispersants, and a need to reevaluate the use of offshore barrier berms in spill response. More particular recommendations included the following:

(1) the USEPA and USCG should establish distinct plans and procedures for responding to a "Spill of National Significance;"

(2) the USEPA and USCG should bolster State and local involvement in oil-spill contingency planning and training and should create a mechanism for local involvement in spill planning and response similar to the Regional Citizens' Advisory Councils mandated by the Oil Pollution Act of 1990;

(3) Congress should provide mandatory funding for oil-spill-response research and development and provide incentives for private-sector research and development;

(4) the USEPA should update and periodically review its dispersant testing protocols for product listing or preapproval, and modify the pre-approval process to include temporal duration, spatial reach, and volume of the spill;

(5) the DOI should require offshore operators to provide detailed plans for source control as part of their oil-spill-response plans and applications for permits to drill; and

(6) the USCG should issue guidance to establish that offshore barrier berms and similar dredged barriers generally will not be authorized as an oil-spill-response measure in the National Contingency Plan or in any Area Contingency Plan.

Recommendations under Category 5 (Oil Spill Commission, 2011e, pp. 31-36), "Advancing Well-Containment Capabilities," included those that responded to a need for government to develop greater source-control expertise, a need to strengthen industry's spill preparedness, a need for improved capability to develop accurate flow rate estimates, and a need for a more robust well design and approval process. More particular recommendations included the following:

(1) the National Response Team (formed after a "spill of national significance") should develop and maintain expertise within the Federal Government to oversee source-control efforts (source control = understanding and controlling a persistent spill);

(2) the DOI should require offshore operators to provide detailed plans for source control as part of their oil-spill-response plans and applications for permits to drill;

(3) the National Response Team should develop and maintain expertise within the Federal Government to obtain accurate estimates of flow rate or spill volume early in a source-control effort; and

(4) the DOI should require offshore operators seeking its approval of proposed well design to demonstrate that (a) well components, including blowout preventer stacks, are equipped with sensors or other tools to obtain accurate diagnostic information (e.g., regarding pressures and the position of blowout preventer rams); and (b) wells are designed to mitigate risks to well integrity during post-blowout containment efforts.

The BOEMRE continues to address the recommendations from the Oil Spill Commission's report regarding safety, oil-spill response, well-containment capabilities, etc., as well as the recommendations from other agencies and investigations. As previously stated, BOEMRE created 11 Implementation Teams tasked with analyzing various aspects of BOEMRE's regulatory structure and helping to implement the reform agenda (USDOI, BOEMRE, 2010b). Teams are considering the various recommendations for improvement received from multiple investigations and analyses, including the Safety Oversight Board, National Commission on the BP Deepwater Horizon Oil Spill, and National Academy of Engineering. Permit applications for drilling projects must meet new standards for well-design, casing, and cementing, and be independently certified by a professional engineer. Standards are being strengthened in the drilling and production stages for equipment, safety practices, environmental safeguards, and oversight. There will be performance-based standards for offshore drilling and production operations, including for equipment, safety practices, environmental safeguards, and management oversight of operations and contractors. New comprehensive environmental analyses of the Gulf of Mexico and the Arctic will be conducted to help inform future leasing and development decisions (USDOI, BOEMRE, 2010c). In addition, new NTL's and regulations are also under development and are in the process of being implemented. The most up-to-date NTL's and new regulations are cited throughout **Chapter 3**, e.g. **Chapter 3.1.1.1.1** ("Seismic Surveying Operations"), **Chapter 3.1.1.1.2** ("Exploration and Delineation Drilling"), **Chapter 3.1.1.2.1** ("Development and Production Drilling"), **Chapter 3.1.1.6.3** ("New and Unusual Technology").

With respect to the Commission's observations on BOEMRE's implementation of NEPA, these recommendations have been taken into consideration in the preparation of this Supplemental EIS and will continue to be considered and acknowledged as this Agency publishes future pre and post lease NEPA documents. This Supplemental EIS is a prelease NEPA document that supplements the Multisale EIS and the 2009-2012 Supplemental EIS, which tier from the 5-Year Program EIS. Tiering in this manner is still valid for prelease documents. The NEPA concept of tiering identified in the Oil Spill Commission Report recommendation targets postlease NEPA activity, specifically categorical exclusions, which are not used in the prelease NEPA process and are not currently being used as part of the approval process for deepwater drilling projects. The Commission's recommendations for postlease activity are being taken into consideration and will be addressed throughout the postlease NEPA process.

Natural Resource Damage Assessment

The mission of the Department of the Interior's NRDA is to restore natural resources injured as a result of oil spills or hazardous substance releases into the environment. Congress authorizes States, Tribes, and Federal resource management agencies to act on behalf of the public as a "trustee" for the purpose of bringing a claim to recover damages necessary to restore or replace injured public resources managed or controlled by the respective States, Tribes, or Federal agency. A damage assessment addresses the public's use of injured resources and their loss, and is the first step toward determining the restoration needs for injured natural resources for the American public. They have a purpose-driven outcome and are not done just for the sake of science.

The Comprehensive Environmental Response, Compensation and Liability Act defines "natural resource damage assessment" as the process of collecting, compiling, and analyzing information,

statistics, or data through prescribed methodologies to determine damages for injuries to natural resources. “Injury” refers to the actual adverse impact or loss of the natural resource resulting either directly or indirectly from exposure to a release or threat of release of oil or a discharge or release of a hazardous substance. An injury assessment investigates and explains the extent of adverse impact to the natural resource. “Damage” is the amount of money sought by the natural resource trustee as appropriate to compensate for the injury through natural resource restoration or replacement projects.

For the DWH event, NOAA Fisheries is coordinating the NRDA and is leading data collection efforts with partners in five states (i.e., Louisiana, Mississippi, Alabama, Florida, and Texas) and DOI. BP is also participating in many of the data collection efforts. Information is now being collected on potential impacts to fish, shellfish, marine mammals, turtles, birds, and other sensitive resources as well as their habitats, including wetlands, beaches, mudflats, bottom sediments, corals, and the water column. The NRDA will also assess any lost human uses of these resources, such as fishing, hunting, and beach closures. Among the many teams now in the field conducting surveys and collecting samples are those programs listed below:

- surveying over 1,800 mi (2,897 km) of shoreline and collecting over 19,500 water, sediment, and animal tissue samples;
- characterizing environmental conditions during more than 70 offshore research cruises, oil on and below the water surface, and the exposure to biological communities;
- documenting the presence of oil and collecting samples for fingerprinting to confirm its origin. (Teams have been conducting initial injury assessment studies at more than 50 shoreline sites a day to collect data on the degree and extent of habitat oiling.);
- monitoring populations of marine mammals and turtles in flyovers, documenting their presence in the impacted areas, and locating stranded animals; and
- evaluating loss of human use, such as recreational beach days, charter boat or diving boat trips, resulting from the spill.

Natural resource restoration is paid for by funds recovered from settlements with responsible parties and are not at the expense of the taxpayer. In addition, settlements often include the recovery of the costs incurred in assessing the damages. These funds are then used to fund further damage assessments. There is no prescribed amount of time set by the Comprehensive Environmental Response, Compensation and Liability Act for the damage assessment to be prepared or for the subsequent restoration process to take place. Each assessment is unique and the amount of time can vary significantly. Damage assessments are often quite complex and can take years to complete. In the case of the DWH event, the acute impacts on resources are liable to be the focus for the NRDA, at least for the initial issue.

Acute Impacts

Acute impacts are primarily those that can be readily identified and measured in the short term. On May 2, 2010, NOAA Fisheries Service announced the first closure of 17,648 km^2 (6,817 mi^2) of coastal and offshore fisheries in State and OCS waters (USDOC, NOAA, 2010). The areas closed to fishing were to rise steadily to a maximum of 225,290 km^2 (86,985 mi^2) on June 21, 2010. Thereafter, closed areas began to reopen until 82,659 km^2 (31,915 mi^2) remained closed on September 21 (USDOC, NOAA, 2010), or approximately 13 percent of Gulf waters. By October 15, 2010, 42,686 km^2 (16,481 mi^2) remained closed, or approximately 7 percent of Gulf waters (USDOC, NOAA, 2010), and by November 15, 2010, 2,697 km^2 (1,041 mi^2) remained closed, or 0.4 percent of Gulf waters (USDOC, NOAA, 2010). Throughout the DWH event, NOAA produced spill trajectory graphics to inform the public about the extent and surface expression of the spill and how it changed over time. The NOAA posted their complete archive of maps on September 16, 2010, shortly before the Macondo well was killed (USDOC, NOAA, NOS, 2010).

On May 2, 2010, the first oiled bird began rehabilitation (Bearden, 2010), and by May 21 early stranding reports identified 186 dead turtles, 43 birds, and 18 marine mammals as being possible spill casualties (Winter, 2010). On May 28, FWS began to keep track of dead and oiled animals that were collected or recovered for rehabilitation at designated stations along the Gulf Coast. The FWS prepared and posted daily Consolidated Fish and Wildlife Collection Reports on the total number and condition of marine mammals, birds, and sea turtles collected in each Gulf State's coastal zone (*Deepwater Horizon* Response, 2010b). The consolidated report for September 17 (USDOI, FWS, 2010a) reported cumulative totals (**Table D-4**).

On May 6, 2010, a Shoreline Cleanup and Assessment Team confirmed the first oil landfall on the beach at Chandeleur Islands. The first tarballs washed ashore on Dauphin Island, Alabama, on May 12, and oil appeared on Pensacola Beach, Florida, and the Gulf Islands National Seashore, Florida and Mississippi, on June 23. On June 4, Dunlap (2010) reported what are probably the best known images of dead and dying birds heavily oiled by the spill, i.e., pelicans and other seabirds from East Grand Terre Island, Louisiana.

On May 26, 2010, the Associated Free Press (2010) reported that UIC recalled 125 boats working on the spill east of New Orleans after workers on three boats reported experiencing nausea, dizziness, headaches, and chest pains; this was the first of the intermittent reports of human health effects of unknown origin that may or may not have been spill-related (working under high heat conditions and dehydration may have been aggravating factors). By June 9, Landau (2010) reported 71 cases of spill-related illnesses and complaints; 50 by workers on offshore rigs or spill cleanup crews and 21 by non-spill workers.

On June 1, 2010, the Federal Government authorized 17,500 National Guard troops from the Gulf Coast States to be paid for by BP: Louisiana (6,000); Mississippi (6,000); Alabama (3,000); and Florida (2,500). The eligible states eventually authorized only small fractions of the total manpower made available. The UIC's spill-response operations began to mobilize ever-increasing numbers of personnel, vessels, aircraft, and shoreline containment boom that serves as level-of-effort metric for responding to the Macondo spill (**Table D-3**). After the well was capped on July 15, 2010, the number of people reported by UIC for spill response peaked at 46,500 on July 10; after that, a gradual ramp-down began in people and equipment deployed.

As of May 25, 2010, UIC reported 85 mi (136 km) of shoreline that had been oiled. By July 27, 11 days after the well was capped, a joint press conference with National Incident Commander Thad Allen and NOAA Administrator Jane Lubchenco reported that approximately 650 mi (1,030 km) of Gulf Coast shoreline had been oiled; 362 mi (583 km) of that in Louisiana (Joint Information Center, 2010). On September 13, Kaufman and Dewan (2010) reported that, as of August 31, NOAA had surveyed 1,796 mi (2,890 km) of Louisiana coast and found 35 mi (56 km) of shoreline to be heavily oiled, 71 mi (114 km) to be moderately oiled, and 115 mi (185 km) to be lightly oiled.

There is disagreement about the amount of Louisiana wetlands oiled by the spill. Robert Barham, Secretary of Louisiana's Department of Wildlife and Fisheries, was quoted in *The Washington Post* on July 26 that 200 mi^2 (128,000 ac; 51,800 ha) of Louisiana's shoreline had been oiled, most of which was wetlands (Fahrenthold, 2010). On July 29, however, Grunwald (2010) reported that UIC's Shoreline Cleanup and Assessment Team found that only about 350 ac (142 ha) of marshes had been oiled to various degrees in Louisiana. On August 2, Jervis (2010) reported that about 108 mi^2 (27,972 ha) of Louisiana marshland were "hit" by oil, with no qualification as to degree of oiling.

On July 31, 2010, two weeks after the flow of oil had stopped from the Macondo well, NOAA's Office of Response of Restoration reported no recoverable surface oil was observable (USDOC, NOAA, NOS, 2010). By July 21, the UIC burn teams found no surface oil to skim and burn. The spill response had involved a total of 411 burns.

The Unified Area Command's Daily Report for August 30 (*Deepwater Horizon* Response, 2010c) reported that approximately 57,000 cumulative tons of solid and oily solid waste had been disposed of in authorized landfills and that 450,000 cumulative barrels of oil and water mixtures or emulsions (e.g., from skimming or oil recovery operations) had been collected during response activities.

Concern remains, however, about the longer-term impact of at-large underwater oil, its fate, and possible ecological damage that could result from it. Several research teams have been in the vanguard to take measurements, among them are Texas A&M, University of Georgia, Woods Hole Oceanographic Institute, and the University of South Florida. On May 16, Gillis (2010) reported that a researcher from

the University of Georgia on the NOAA R/V *Pelican* detected the first underwater plumes of fine droplets of suspended oil at various depth levels. On May 27, scientists from the University of South Florida and the Florida Fish and Wildlife Research Institute reported an area of dissolved hydrocarbons in the subsurface near the Macondo spill (Chachere, 2010a). On June 22, Steenhyusen (2010) reported that John Kessler at Texas A&M had found elevated concentrations of methane dissolved in seawater. On September 10, Harris (2010) reported that Samantha Joye of the University of Georgia on the R/V *Oceanus* had discovered accumulations of oil and oily residues up to 5 cm (2 in) thick in cores from the sea bottom in water depths of 300-2,000 ft (91-609 m). A similar find was reported by David Hollander on August 17 on the University of South Florida's website (Chachere, 2010b). Dr. Joye hypothesized that the mucosa secreted from marine bacteria, perhaps in combination with dispersant chemicals, attached to floating oil droplets, entrained the oil, and caused it to sink (Joye, 2010). On September 16, Valentine et al. (2010) reported that microbes were consuming propane and ethane, components of dissolved gas that are more easily consumed by low-diversity bacterial blooms, and not consuming much methane. On September 17, 2010, John Kessler and Texas A&M's team on the NOAA R/V *Pisces* completed a 10-day mission to track the fate of oil and methane that may remain in the deep water of the Gulf, and by January 6, 2011, they reported that levels of methane in the Gulf of Mexico had returned to near-normal levels (Kessler et al., 2011).

Further discussion of impacts on each resource is reported in the impacts analysis for each affected resource in **Chapter 4**.

References Cited

Ashworth, K. 2010. Written communication. November 10, 2010, multiagency teleconference summary. E-mail from Kenneth Ashworth to Thomas Bjerstedt, December 7, 2010.

Associated Press. 2010. Kevin Costner wants cleanup devices kept near oil rigs as a precaution. *The Times Picayune*, June 17, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/06/kevin_costner_wants_cleanup_de.html. Accessed February 11, 2011.

Associated Free Press. 2010. US oil spill clean-up boats recalled after crews fall ill. Google News. May 27, 2010. Internet website: http://www.google.com/hostednews/afp/article/ALeqM5jFtkL4pNNCRLe2VAzkUzE3zMPc9w. Accessed January 13, 2011.

Ball, J. 2010. Louisiana curtails coastal plan. *The New York Times*, October 6, 2010. http://online.wsj.com/article/SB10001424052748704847104575532213694011130.html. Accessed January 13, 2011.

Bearden, T. 2010. Dispatch from Louisiana: One bird covered in oil, many cameras. PBS News Hour. May 2, 2010. Internet website: http://www.pbs.org/newshour/rundown/2010/05/dispatch-from-louisiana-one-bird-covered-in-oil-many-cameras.html#. Accessed January 13, 2011.

British Petroleum (BP). 2010. *Deepwater Horizon* accident investigation report. 192 pp. Internet website: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/incident_response/STAGING/local_assets/downloads_pdfs/Deepwater_Horizon_Accident_Investigation_Report.pdf. Posted September 8, 2010.

Bromwich, M.R. 2010. Report regarding the current suspension of certain offshore permitting and drilling activities on the outer continental shelf. Decision Memo to Secretary of the Interior. October 1, 2010. Internet website: http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=64703. Accessed March 1, 2011.

Cart, J. and R. Simon. 2010. Gulf oil spill: BP ordered to dramatically scale back use of dispersants. *The Los Angeles Times*. May 24, 2010. Internet website: http://latimesblogs.latimes.com/greenspace/2010/05/gulf-oil-spill--1.html. Accessed January 13, 2011.

Chachere, V. 2010a. Invisible oil detected in Gulf. University of South Florida, News. Internet website: http://usfweb3.usf.edu/absolutenm/templates/?a=2362&z=31. Posted May 28, 2010. Accessed January 13, 2011.

Chachere, V. 2010b. USF scientists detect oil on Gulf floor. University of South Florida, News. Internet website: http://usfweb3.usf.edu/absoluteNM/templates/?a=2604&z=123. Posted August 17, 2010. Accessed January 13, 2011.

Deepwater Horizon Response. 2010a. Deepwater Horizon Response Unified Area Command daily report, July 21, 2010.

Deepwater Horizon Response. 2010b. Consolidated Fish and Wildlife collection reports. The official site of the Deepwater Horizon Unified Area Command. Internet website: http://www.restorethegulf.gov/news/transcripts-docs. Updated September 7, 2010. Accessed September 8, 2010.

Deepwater Horizon Response. 2010c. Deepwater Horizon Response Unified Area Command daily report, August 31, 2010.

Dunlap, D.W. 2010. Putting a face on the Gulf oil leak. *The New York Times*. June 4, 2010. Internet website: http://lens.blogs.nytimes.com/2010/06/04/assignment-35/. Accessed January 13, 2011.

Fahrenthold, D. 2010. How oil-damaged marsh grasses recover could affect Gulf's rebound. *The Washington Post*. July 26, 2010. Internet website: http://www.washingtonpost.com/wp-dyn/content/article/2010/07/25/AR2010072502620.html. Accessed February 14, 2011.

Federal Interagency Solutions Group. 2010. Oil budget calculator *Deepwater Horizon* technical documentation. Oil Budget Calculator Science and Engineering Team. Report to the National Incident Command, November 2010. 49 pp. + app. Internet website: http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc_Full_HQ-Print_111110.pdf.

Fountain, H. 2010a. The 'super skimmer' that wasn't. *The New York Times*. Green: Blog about energy and the environment, July 20, 2010. Internet website: http://green.blogs.nytimes.com/2010/07/20/the-super-skimmer-that-wasnt/. Accessed January 13, 2011.

Fountain, H. 2010b. BP considers new plan to permanently seal well. *The New York Times*. July 19, 2010. Internet website: http://www.nytimes.com/2010/07/20/us/20oilspill.html. Accessed January 13, 2011.

Fountain, H. 2010c. BP begins last step in sealing stricken well in the Gulf. *The New York Times*. September 17, 2010. Internet website: http://www.nytimes.com/2010/09/18/us/18well.html. Accessed January 13, 2011.

Gelsi, S. 2010. BP to increase dispersants under water to break up spill. Marketwatch. May 4, 2010. Internet website: http://www.marketwatch.com/story/bp-to-increase-dispersants-to-break-up-oil-spill-2010-05-04. Accessed January 13, 2011.

Gillis, J. 2010. Giant plumes of oil forming under the Gulf. *The New York Times*. May 15, 1010. Internet website: http://www.nytimes.com/2010/05/16/us/16oil.html. Accessed January 13, 2011.

Grunwald, M. 2010. The BP spill: Has the damage been exaggerated? *Time Magazine*. July 29, 2010. Internet website: http://www.time.com/time/printout/0,8816,2007202,00.html. Accessed January 13, 2011.

Hammer, D. 2010a. 5 key human errors, colossal mechanical failure led to fatal Gulf oil rig blowout. *The Times Picayune*. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/09/5_key_human_errors_colossal_me.html#incart_mce. Updated September 5, 2010. Accessed September 8, 2010.

Hammer, D. 2010b. Only 160 deepwater rig workers have applied for aid from $100 million BP fund. *The Times Picayune*. September 14, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/09/only_160_deepwater_rig_workers.html. Accessed January 13, 2011.

Harris, R. 2010. Scientists find thick layer of oil on seafloor. National Public Radio (online). September 10, 2010. Internet website: http://www.npr.org/templates/story/story.php?storyId=129782098. Accessed January 13, 2011.

Jernelöv, A. 2010. The threats from oil spills: Now, then, and in the future. Ambio 39:353-366. Internet website: http://www.springerlink.com/content/303223683645l54u/fulltext.pdf.

Jervis, R. 2010. La. marshes damaged by oil, but surprisingly resilient. *USA Today*. August 2, 2010. Internet website: http://www.usatoday.com/news/nation/environment/2010-08-02-1Amarshes02_CV_N.htm. Accessed March 22, 2011.

Jindal, B. 2010. Governor Jindal letter to President Obama and Secretary Salazar: Severe impacts of moratorium on deepwater drilling. Press Release, June 3, 2010. Internet website: http://emergency.louisiana.gov/Releases/06032010-letter.html. Accessed January 13, 2011.

Joint Information Center. 2010. The ongoing administration-wide response to the deepwater BP oil spill. Admiral Allen and NOAA Administrator Lubchenco provide an update on the BP oil spill response. July 27, 2010. Internet website: http://www.restorethegulf.gov/release/2010/07/27/ongoing-administration-wide-response-deepwater-bp-oil-spill. Accessed January 13, 2011.

Joye, S. 2010. Focusing in on oil, scientist' log from September 5, 2010, aboard the R/V *Oceanus* in the northern Gulf of Mexico. Gulf Oil Blog, University of Georgia, Dept. of Marine Sciences. Internet website: http://gulfblog.uga.edu/2010/09/focusing-in-on-oil. Accessed September 15, 2010.

Kaufman, L. and S. Dewan. 2010. Gulf may avoid direst predictions after oil spill. *The New York Times*. September 13, 2010. Internet website: http://www.nytimes.com/2010/09/14/science/earth/14spill.html?pagewanted=2. Accessed March 1, 2011.

Kaufman, L. and C. Krauss. 2010. "Top kill" can't halt oil spill; BP on to next option. *Denver Post*, May 30, 2010. Internet website: http://www.denverpost.com/recommended/ci_15191222?source=pkg. Accessed January 13, 2011.

Kessler, J.D., D.L Valentine, M.C. Redmond, M. Du., E.W. Chan, S.D. Mendes, E.W. Quiroz, C.J. Villanueva, S.S. Shusta, L.M. Werra, S.A. Yvon-Lewis, and T.C. Weber. 2011. A persistent oxygen anomaly reveals the fat of spilled methane in the deep Gulf of Mexico. Science Express. Internet website: http://www.sciencemag.org/content/early/2011/01/05/science.1199697. Posted January 6, 2011. Accessed January 13, 2011.

Krauss, C., Fountain, H., and J.M. Broder. 2010. Acrimony behind the scenes of Gulf oil spill. *The New York Times*. Internet website: http://www.nytimes.com/2010/08/27/us/27well.html. Posted May 26, 2010. Accessed September 10, 2010.

Landau, E. 2010. Gulf States tracking oil-related illnesses. CNN, June 9, 2010, 7:10 p.m. EDT. Internet website: http://articles.cnn.com/2010-06-09/health/oil.spill.health.impact_1_oil-leak-oil-related-bp?_s=PM:HEALTH. Accessed January 13, 2011.

Lavoie, D., J.G., Flocks, J.L. Kindinger, A.H. Sallengaer, and D.C. Twichell. 2010. Effects of building a sand barrier berm to mitigate the effects of the Deepwater Horizon oil spill on Louisiana marshes: U.S. Dept. of the Interior, Geological Survey Open-File Report 2010-1108. 7 pp. Internet website: http://pubs.usgs.gov/of/2010/1108/pdf/of2010-1108.pdf.

Lubchenco, J.L., M. McNutt, B. Lehr, M. Sogge, M. Miller, S. Hammond, and W. Conner. 2010. BP *Deepwater Horizon* oil budget: What happened to the oil? Internet website: http://www.noaanews.noaa.gov/stories2010/PDFs/OilBudget_description_%2083final.pdf. Accessed September 8, 2010.

Mowbray, R. 2010. BP attaches shutoff valve, readies big box to catch oil. *The Times-Picayune*. May 5, 2010. Internet website: http://www.nola.com/news/t-p/frontpage/index.ssf?/base/news-14/127304047687330.xml&coll=1. Accessed March 22, 2011.

Muir, D., 2010. Gov. Bobby Jindal orders National Guard to build barrier wall off Louisiana shore. ABC News. June 14, 2010. Internet website: http://abcnews.go.com/WN/article/bp-oil-spill-gov-bobby-jindal-orders-national/story?id=10914348. Accessed January 13, 2011.

National Academy of Engineers. 2010. Interim report on causes of the *Deepwater Horizon* oil rig blowout and ways to prevent such events. November 16, 2010. The National Academies,

Washington DC. Internet website: http://www.nationalacademies.org/includes/DH_Interim_Report_final.pdf.

Nerenberg, J. 2010. First peer-reviewed numbers on BP oil spill disaster released. Internet website. http://www.fastcompany.com/1690791/first-peer-reviewed-numbers-of-bp-oil-spill-disaster-unveiled. Posted September 23, 2010. Accessed September 27, 2010.

Oil Spill Commission. 2011a. Stopping the spill: The five-month effort to kill the Macondo well. Staff Working Paper No. 6. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Containment%20Working%20Paper.pdf. Posted November 22, 2010. Updated January 11, 2011.

Oil Spill Commission. 2011b. The story of the Louisiana berms project. Staff Working Paper No. 8. 45 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/The_Story_of_the_Louisiana_Berms_Project.pdf. Posted December 6, 2010. Updated January 11, 2011.

Oil Spill Commission. 2011c. The amount and fate of the oil. Staff Working Paper No. 3. 34 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Amount%20and%20Fate%20of%20the%20Oil%20Working%20Paper.pdf. Posted October 6, 2010. Updated January 11, 2011.

Oil Spill Commission. 2011d. Deep water: The Gulf oil disaster and the future of offshore drilling. Report to the President, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Final Report. Posted January 11, 2011. 306 pp. + apps. Internet website: http://www.oilspillcommission.gov/final-report.

Oil Spill Commission. 2011e. Deep water: The Gulf oil disaster and the future of offshore drilling. Report to the President, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Recommendations for Decisionmakers. January 2011. 63 pp. Internet website: http://www.oilspillcommission.gov/sites/default/files/documents/OSC_Deep_Water_Summary_Recommendations_FINAL.pdf.

Polson, J. 2010. Oil spill from sunken Gulf platform may be dispersed by storms. BloombergBusinessweek. April 24, 2010. Internet website: http://www.businessweek.com/news/2010-04-24/oil-spill-from-sunken-gulf-platform-may-be-dispersed-by-storms.html. Accessed January 13, 2011.

Power, S. 2010. Costly sand piles caught little gulf oil. *The Wall Street Journal*. December 17, 2010. Internet website: http://online.wsj.com/article/SB10001424052748703395204576023673494788638.html. Accessed March 1, 2011.

RestoreTheGulf.gov. 2010a. Statement from Admiral Allen on the successful completion of the relief well. September 19, 2010. Internet website: http://www.restorethegulf.gov/release/2010/09/19/statement-admiral-allen-successful-completion-relief-well. Accessed January 13, 2011.

RestoreTheGulf.gov. 2010b. Federal interagency group issues peer-reviewed “oil budget” technical documentation. Internet website: http://www.restorethegulf.gov/release/2010/11/23/federal-interagency-group-issues-peer-reviewed-%E2%80%9Coil-budget%E2%80%9D-technical-documentati. Posted November 23, 2010. Accessed December 30, 2010.

RestoreTheGulf.gov. 2010c. America’s Gulf Coast: A long-term recovery plan after the *Deepwater Horizon* oil spill. 104 pp. + app. Report dated September 2010. Internet website: http://www.restorethegulf.gov/sites/default/files/documents/pdf/gulf-recovery-sep-2010.pdf. Accessed January 13, 2011.

RestoreTheGulf.gov. 2011. Transcripts and docs. Internet website: http://www.restorethegulf.gov/news/transcripts-docs. Accessed March 11, 2011.

Robbins, L. 2010. After earlier troubles, BP says it restored cap. *The New York Times*. June 23, 2010. Internet website: http://www.nytimes.com/2010/06/24/us/24spillweb.html. Accessed January 13, 2011.

Robertson, C. 2010. Size of spill in Gulf of Mexico is larger than thought. *The New York Times*. April 28, 2010. Internet website: http://www.nytimes.com/2010/04/29/us/29spill.html?pagewanted=all. Accessed January 13, 2011.

Rudolf, J.C. 2010a. Louisiana and scientists spar over how to stop oil. *The New York Times*. July 6, 2010. Internet website: http://www.nytimes.com/2010/07/07/science/earth/07rocks.html. Accessed January 13, 2011.

Rudolf, J.C. 2010b. Louisiana Builds Barriers Even as Oil Disperses. *The New York Times*. October 21, 2010. Internet website: http://www.nytimes.com/2010/10/22/us/22berms.html. Accessed January 13, 2011.

Scott, R.T. 2010. Construction of sand berms continues on Louisiana coast. *The Times Picayune*. August 5, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/08/construction_of_sand_berms_con.html. Accessed January 13, 2011.

Spotts, P. 2010. Scientists team up to attack Louisiana's Gulf oil spill berm plan. Christian Science Monitor. July 23, 2010. Internet website: http://www.csmonitor.com/Environment/2010/0723/Scientists-team-up-to-attack-Louisiana-s-Gulf-oil-spill-berm-plan. Accessed January 13, 2011.

State of Louisiana. Office of Coastal Protection and Restoration Authority. 2010. Barrier berm update. Internet website: http://coastal.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&nid=96&pnid=75&pid=87&catid=0&elid=0. Posted September 15, 2010. Accessed January 13, 2010.

State of Louisiana. Office of the Governor. 2010. Gov. Jindal views heavy oil impact off Louisiana coast, says state and coastal leaders continue to move forward with response plans. Internet website: http://gov.louisiana.gov/index.cfm?md=newsroom&tmp=detail&articleID=2197. Accessed March 22, 2011.

Steenhuysen, J. 2010. Methane in Gulf "astonishingly high": U.S. scientist. Reuters. June 22, 2010. Internet website: http://www.reuters.com/article/idUSTRE65L6IA20100622. Accessed January 13, 2011.

Tankersley, J. 2010a. Energy secretary says 'top kill' should have been tried earlier. *Los Angeles Times*. June 22, 2010. Internet website: http://articles.latimes.com/2010/jun/22/nation/la-na-chu-qa-20100622. Accessed January 13, 2011.

Tankersley, J. 2010b. Second pipe may have crippled BP well's defense mechanism. *Los Angeles Times*. June 29, 2010. Internet website: http://articles.latimes.com/2010/jun/29/news/sc-dc-oil-spill-pipes-20100626. Accessed January 13, 2011.

The White House. 2010. Establishing the Gulf Coast Ecosystem Restoration Task Force. Office of the Press Secretary, Executive Order, October 5, 2010. Internet website: http://www.whitehouse.gov/the-press-office/2010/10/05/executive-order-gulf-coast-ecosystem-restoration-task-force.

The White House Blog. 2010. Secretary of Defense approves request for two C-130 aircrafts to respond. April 30, 2010. Internet website: http://www.whitehouse.gov/blog/2010/05/05/ongoing-administration-wide-response-deepwater-bp-oil-spill. Accessed January 13, 2011.

Urbina, I. 2010. BP used riskier method to seal well before blast. *The New York Times*. Internet website: http://www.nytimes.com/2010/05/27/us/27rig.html. Posted May 26, 2010. Accessed February 14, 2011

U.S. Dept. of Commerce. 2010. Estimating the economic effect of the deepwater drilling moratorium on the Gulf Coast economy: Inter-agency report, September 16, 2010. Report presented at the Department of Commerce Testimony—111th Congress by Rebecca Blank, Under Secretary for Economic Affairs, U.S. Dept. of Commerce. 25pp. Internet website: http://www.commerce.gov/sites/default/files/documents/2010/november/blank091610_report.pdf. Accessed December 12, 2010.

U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. 2010. *Deepwater Horizon*/BP oil spill: Size and percent coverage of fishing area closures due to BP oil spill. Internet website: http://sero.nmfs.noaa.gov/ClosureSizeandPercentCoverage.htm. Updated November 15, 2010. Accessed January 13, 2011.

U.S. Dept. of Commerce. National Oceanographic and Atmospheric Administration. National Ocean Service. 2010. *Deepwater Horizon* trajectory map archive. Office of Response and Restoration. Internet website: http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY%28entry_subtopic_topic%29=entry_id,subtopic_id,topic_id&entry_id(entry_subtopic_topic)=830&subtopic_id(entry_subtopic_topic)=2&topic_id(entry_subtopic_topic)=1. Posted September 16, 2010. Accessed February 14, 2011.

U.S. Dept. of Energy. 2010. *Deepwater Horizon* response. Internet website: http://www.energy.gov/open/oilspilldata.htm. Posted July 28, 2010. Accessed September 15, 2010.

U.S. Dept. of Homeland Security. Coast Guard. 2010. *Deepwater Horizon* response daily report. August 3, 2010. Coast Guard Unified Area Command.

U.S. Dept. of Homeland Security and U.S. Environmental Protection Agency. 2010. Letter to Dr. Tony Hayward from Janet Napolitano and Lisa P. Jackson. May 20, 2010 Internet website: http://www.epa.gov/bpspill/dispersants/bp-hayward-dhs-epa.pdf. Accessed January 13, 2011.

U.S. Dept. of the Interior. 2010a. Flow rate group provides preliminary best estimate of oil flowing from BP oil well. Press Release. Internet website: http://www.doi.gov/news/pressreleases/Flow-Rate-Group-Provides-Preliminary-Best-Estimate-Of-Oil-Flowing-from-BP-Oil-Well.cfm. Updated June 7, 2010. Accessed February 14, 2011.

U.S. Dept. of the Interior. 2010b. Increased safety measures for energy development on the outer continental shelf, May 27, 2010. U.S. Dept. of the Interior, Washington, DC. 44 pp. Internet website: http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=33598.

U.S. Dept. of the Interior. 2010c. Outer Continental Shelf Safety Oversight Board, report to Secretary of the Interior Ken Salazar. U.S. Dept. of the Interior, Washington, DC. September 1, 2010. 37 pp. Internet website: http://www.doi.gov/news/pressreleases/loader.cfm?csModule=security/getfile&PageID=43677.

U.S. Dept. of the Interior. 2010d. Salazar launches safety and environmental protection reforms to toughen oversight of offshore oil and gas operations. Press Release. May 11, 2010. U.S. Dept. of the Interior. Internet website: http://www.doi.gov/news/pressreleases/Salazar-Launches-Safety-and-Environmental-Protection-Reforms-to-Toughen-Oversight-of-Offshore-Oil-and-Gas-Operations.cfm.

U.S. Dept. of the Interior. 2010e. Salazar divides MMS's three conflicting missions. Press Release. May 19, 2010. Internet website: http://www.doi.gov/news/pressreleases/Salazar-Divides-MMSs-Three-Conflicting-Missions.cfm. Accessed January 13, 2011.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010a. Modifications to suspension of deepwater drilling operations: Environmental assessment and finding of no significant impact (October 12, 2010). U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Herndon, VA. 43 pp. Internet website: http://www.boemre.gov/eppd/PDF/EAModificationsSuspension10122010.pdf.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010b. BOEMRE Director testifies before the National Commission on the BP Deepwater Horizon Oil Spill. Press Release. November 9, 2010. Internet website: http://www.boemre.gov/ooc/press/2010/press1109.htm. Accessed March 25, 2011.

U.S. Dept. of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement. 2010c. Reorganization and regulatory reform—supplemental environmental impact statement (SEIS). Internet website: http://www.boemre.gov/ReorganizationRegulatoryReform_SEIS.htm. Accessed March 25, 2011.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010a. FWS *Deepwater Horizon* oil spill response. Weekly bird impact data and consolidated wildlife reports. Internet website: http://www.fws.gov/home/dhoilspill/collectionreports.html#wildlifetable. Posted September 17, 2010. Accessed September 20, 2010.

U.S. Dept. of the Interior. Fish and Wildlife Service. 2010b. Bird impact data from DOI-ERDC database download 30 Nov. 2010: Weekly bird impact data and consolidated wildlife reports. 3 pp. Internet website: http://www.fws.gov/home/dhoilspill/pdfs/Bird%20Data%20Species%20Spreadsheet%2011302010.pdf.

U.S. Dept. of the Interior. Office of the Inspector General. 2010. A new horizon: Looking to the future of the Bureau of Ocean Energy Management, Regulation and Enforcement. No. CR-EV-MMS-0015-2010. Washington DC. 82 pp. Internet website: http://www.doioig.gov/images/stories/reports/pdf/A%20New%20Horizon%20Public.pdf.

U.S. Environmental Protection Agency. 2010. Letter from L. Jackson to D. Rainey. May 26, 2010. Internet website: http://www.epa.gov/bpspill/dispersants/Rainey-letter-052610.pdf. Accessed January 13, 2011.

U.S. Dept. of Homeland Security and U.S. Environmental Protection Agency. 2010. Letter to Dr. Tony Hayward from Janet Napolitano and Lisa P. Jackson. May 20, 2010 Internet website: http://www.epa.gov/bpspill/dispersants/bp-hayward-dhs-epa.pdf. Accessed January 13, 2011.

Valentine, D.L., J.D. Kessler, M.C. Redmond, S.D. Mendes, M.B. Heintz, C. Farwell, L. Hu, F.S. Kinnaman, S. Yvon-Lewis, M. Du, E.W. Chan, F. Garcia Tigreros, and C.J. Villaneuva. 2010. Propane respiration jump-starts microbial response to a deep oil spill. Science Express. Internet website: http://www.sciencemag.org/cgi/content/abstract/science.1196830. Posted September 16, 2010.

Webb, T. 2010. BP oil spill: Failed safety device on *Deepwater Horizon* rig was modified in China. *The Observer*. Internet website: http://www.guardian.co.uk/environment/2010/jul/18/deepwater-horizon-blow-out-preventer-china. Posted July 18, 2010. Accessed September 22, 2010.

White, J. 2010. Gulf of Mexico oil spill response leader Thad Allen to step down Oct. 1. *The Times Picayune*. September 24, 2010. Internet website: http://www.nola.com/news/gulf-oil-spill/index.ssf/2010/09/gulf_of_mexico_oil_spill_respo_2.html. Accessed January 13, 2011.

Winter, A. 2010. Gulf oil spill creates 'giant experiment' in marine toxicology. *The New York Times*. May 21, 2010. Internet website: http://www.nytimes.com/gwire/2010/05/21/21greenwire-gulf-oil-spill-creates-giant-experiment-in-mari-1284.html. Accessed January 13, 2011.

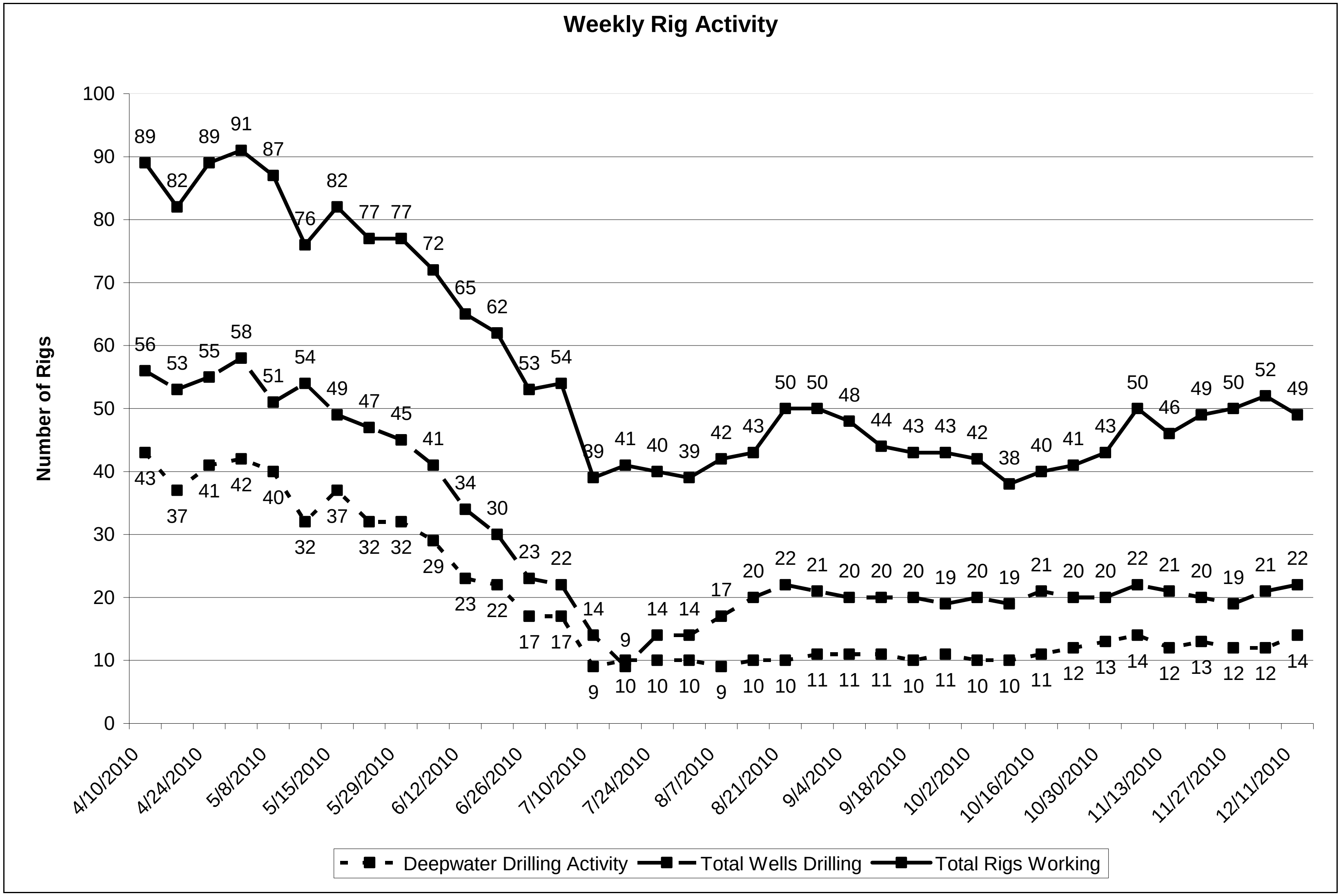

Figure D-1. Deepwater Drilling Activity, Total Wells Drilling, and Total Rigs Working from mid-April to December 2010.

Table D-1

Largest Marine Blowouts Prior to the *Deepwater Horizon* Event

Well	Country	Year	Amount Spilled (bbl)*	Circumstances
Ixtoc I	Mexico	1979	3,467,500	From PEMEX
Nuwruz	Iran	1983-1985	730,000	After attack by Iraqi planes
Nowruz	Iran	1983	292,000	After oil platform hit by a tanker
Ecofisk	Norway	1977	197,100	Not reported
Funiwa 5	Nigeria	1980	189,800	Not reported
Montara	Australia	2009	146,000	Not reported

* From Jernelöv (2010) who reported amount spilled in tons, converted here to bbl: 1 ton = 7.3 U.S. bbl.

Table D-2

Largest Oil Spills from Tankers

Rank	Ship	Year	Amount Spilled (bbl)*	Location
1	*Atlantic Empress*	1979	2,095,100	Off Tobago, West Indies
2	*ABT Summer*	1991	1,898,000	700 nautical miles off Angola
3	*Castillo de Bellver*	1983	1,839,600	Off Saldanha Bay, South Africa
4	*Amoco Cadiz*	1978	1,627,900	Off Brittany, France
5	*Haven*	1991	1,051,200	Genoa, Italy
6	*Odyssey*	1988	963,600	700 nautical miles off Nova Scotia, Canada
7	*Torrey Canyon*	1967	868,700	Isles of Scilly, United Kingdom
8	*Sea Star*	1972	839,500	Gulf of Oman
9	*Irenes Serenade*	1980	730,000	Navarino Bay, Greece
10	*Urquiola*	1976	730,000	A Corun˜a, Spain
11	*Hawaiian Patriot*	1977	693,500	300 nautical miles off Honolulu
12	*Independenta*	1979	693,500	Bosphorus, Turkey
13	*Jakob Maersk*	1975	642,400	Oporto, Portugal
14	*Braer*	1993	620,500	Shetland Islands, United Kingdom
15	*Khark 5*	1989	584,000	120 nautical miles off Atlantic coast of Morocco

* From Jernelöv (2010) who reported amount spilled in tons, converted here to bbl: 1 ton = 7.3 U.S. bbl.

Table D-3

Personnel, Vessels, Aircraft, and Containment Boom Deployed for *Deepwater Horizon* Spill Response Activity*

Date	Personnel	Vessels	Aircraft	Containment Boom Deployed (ft)
April 22	N/R	2	5	N/R
April 25	500	30	N/R	21,340
April 30	2000	75	N/R	217,000
May 5	7,900	200	N/R	564,991
May 10	10,000	290	N/R	1,000,000
May 15	17,500	600	N/R	1,250,000
May 20	24,000	1,000	N/R	1,990,000
May 25	22,000	1,200	N/R	1,800,000
May 30	20,000	1,400	N/R	1,900,000
June 5	20,000	2,600	N/R	2,100,000
June 10	24,000	4,400	64	2,200,000
June 15	29,000	5,000	93	2,370,000
June 20	33,000	6,100	107	2,470,000
June 25	37,000	6,510	96	2,600,000
June 30	42,000	6,850	122	2,760,000
July 5	45,000	7,040	113	2,950,000
July 10	46,500	6,840	120	3,060,000
July 15	44,000	6,870	119	3,270,000
July 20	42,000	5,300	120	3,460,000
July 25	30,000	3,600	108	3,410,000
July 30	32,600	4,400	97	3,400,000
August 5	31,800	4,800	90	3,000,000
August 10	31,100	4,900	75	2,400,000
August 15	28,200	4,300	75	2,200,000
August 20	30,200	4,300	72	2,300,000
August 25	30,294	4,375	72	2,300,000
August 28+	29,705	5,059	64	2,300,000
September 5	28,000	++4,000	N/R	1,570,000
September 10	27,000	3,600	N/R	999,000
September 15	25,900	4,700	N/R	714,000
September 17**	25,200	2,600	N/R	670,000
October 12	16,292	N/R	N/R	19,540
November 22	8,198	552	N/R	N/R
December 1	6,471	451	N/R	N/R
December 10	6,579	382	N/R	N/R
December 23	6,170	260	N/R	N/R
January 6	5,428	345	N/R	N/R
January 13	5,428	348	N/R	N/R

N/R = Not reported.

* Compiled from UIC Daily Operations Reports from the official *Deepwater Horizon* Spill Response website or from the RestoreTheGulf.gov website (RestoreTheGulf.gov, 2011).

** Last date of daily and itemized reporting.

\+ No reports for August 29 or September 1.

++ Aircraft included in vessel count from this point forward.

Table D-4

Cumulative Totals for Oiled and Nonoiled Animals Collected
as Part of *Deepwater Horizon* Spill Response Activity*

Animal	Visibly Oiled, Alive	Visibly Oiled, Dead	Not Visibly Oiled, Alive	Not Visibly Oiled, Dead
Birds	2,071	2,240	0	3,705
Sea Turtles	453	17	75	121
Marine Mammals	2	4	7	84

As of September 17, 2010.
Source: USDOI, FWS, 2010b.

APPENDIX E

RECENT PUBLICATIONS OF THE ENVIRONMENTAL STUDIES PROGRAM, GULF OF MEXICO OCS REGION, 2006—PRESENT

APPENDIX E. RECENT PUBLICATIONS OF THE ENVIRONMENTAL STUDIES PROGRAM, GULF OF MEXICO OCS REGION, 2006–PRESENT

Published in 2010	
Study Number	Title
MMS 2010-001	*Proceedings: USA-Mexico Workshop on the Deepwater Physical Oceanography of the Gulf of Mexico, June 2007*
MMS 2010-002	*Proof of Concept for Platform Recruited Reef Fish, Phase 1: Do Platforms Provide Habitat for Subadult Red Snapper?*
MMS 2010-007	*Assessment of Marginal Production in the Gulf of Mexico and Lost Production from Early Decommissioning*
MMS 2010-015	*Low-Frequency Variability of Currents in the Deepwater Eastern Gulf of Mexico*
MMS 2010-016	*Trophic Aspects of Sperm Whales (*Physeter macrocephalus*) in the Northern Gulf of Mexico Using Stable Isotopes of Carbon and Nitrogen*
BOEMRE 2010-039	*Bank Erosion of Navigation Canals in the Western and Central Gulf of Mexico*
Published in 2009	
Study Number	Title
MMS 2009-010	*Quality Control and Analysis of Acoustic Doppler Current Profiler Data Collected on Offshore Platforms of the Gulf of Mexico*
MMS 2009-013	*Foraminiferal Communities of Bathyal Hydrocarbon Seeps, Northern Gulf of Mexico: A Taxonomic, Ecologic, and Geologic Study*
MMS 2009-023	*Loop Current Frontal Eddies Based on Satellite Remote Sensing and Drifter Data*
MMS 2009-032	*Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity*
MMS 2009-039	*Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study: Final Report*
MMS 2009-043	*Blue Crab (*Callinectes sapidus*) Use of the Ship/Trinity/Tiger Shoal Complex as a Nationally Important Spawning/Hatching/Foraging Ground: Discovery, Evaluation, and Sand Mining Recommendations Based on Blue Crab, Shrimp, and Spotted Seatrout Findings*
MMS 2009-046	*Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico, Interim Report 2*
MMS 2009-048	*Outer Continental Shelf (OCS)-Related Pipelines and Navigation Canals in the Western and Central Gulf of Mexico: Relative Impacts on Wetlands Habitats and Effectiveness of Mitigation*
MMS 2009-050	*Observation of the Deepwater Manifestation of the Loop Current and Loop Current Rings in the Eastern Gulf of Mexico*

MMS 2009-051	*Proceedings: Twenty-fifth Gulf of Mexico Information Transfer Meeting, January 2009*
 MMS 2009-055 MMS 2009-056 MMS 2009-057 MMS 2009-058	*Synthesis, Analysis, and Integration of Meteorological and Air Quality Data for the Gulf of Mexico Region* *Volume I: User's Manual for the Gulf of Mexico Air Quality Database (Version 1.0)* *Volume II: Technical Reference Manual for the Gulf of Mexico Air Quality Database* *Volume III: Data Analysis* *Volume IV: Cart Analysis of Modeling Episode Days*
MMS 2009-059	*Evaluation of Oil and Gas Platforms on the Louisiana Continental Shelf for Organisms with Biotechnology Potential*
MMS 2009-060	*Modeling Waves and Currents Produced by Hurricanes Katrina, Rita, and Wilma*
Published in 2008	
Study Number	Title
MMS 2008-001	*Deepwater Currents in the Eastern Gulf of Mexico: Observations at 25.5°N and 87°W*
MMS 2008-006	*Sperm Whale Seismic Study in the Gulf of Mexico: Synthesis Report*
MMS 2008-009	*Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico: Interim Report 1*
MMS 2008-012	*Proceedings: Twenty-Fourth Gulf of Mexico Information Transfer Meeting, January 2007*
MMS 2008-015	Lophelia *Reef Megafaunal Community Structure, Biotopes, Genetics, Microbial Ecology, and Geology (2004-2006)* NOTE: This study was conducted by the U.S. Geological Survey (USGS) for the Agency's Headquarters' Office, and it was funded by USGS.
MMS 2008-017	*Examination of the Development of Liquefied Natural Gas on the Gulf of Mexico*
MMS 2008-018	*Viosca Knoll Wreck: Discovery and Investigation of an Early Nineteenth-Century Wooden Sailing Vessel in 2,000 Feet of Water*
MMS 2008-019	*Post-Hurricane Assessment at the East Flower Garden Bank Long-Term Monitoring Site: November 2005*
MMS 2008-022	*Effects of Subsea Processing on Deepwater Environments in the Gulf of Mexico*
MMS 2008-024	*Executive Summary: 3rd International Deep-Sea Coral Symposium in Miami*
 MMS 2008-027 MMS 2008-028	*Long-Term Monitoring at the East and West Flower Garden Banks, 2004-2005—Interim Report* *Volume I: Technical Report* *Volume II: Appendices*
MMS 2008-029	*Five-Year Meteorological Datasets for CALMET/CALPUFF and OCD5 Modeling of the Gulf of Mexico Region*
 MMS 2008-030 MMS 2008-031	*Study of Deepwater Currents in the Northwestern Gulf of Mexico* *Volume I: Executive Summary* *Volume II: Technical Report*

MMS 2008-042 MMS 2008-043 MMS 2008-044 MMS 2008-045 MMS 2008-046 MMS 2008-047	*History of the Offshore Oil and Gas Industry in Southern Louisiana* *Volume I: Papers on the Evolving Offshore Industry* *Volume II: Bayou Lafourche—Oral Histories of the Oil and Gas Industry* *Volume III: Morgan City's History in the Era of Oil and Gas—Perspectives of Those Who Were There* *Volume IV: Terrebonne Parish* *Volume V: Guide to the Interviews* *Volume VI: A Collection of Photographs*
MMS 2008-048	*Platform Debris Fields Associated with the Blue Dolphin (Buccaneer) Gas and Oil Field Artificial Reef Sites Offshore Freeport, Texas: Extent, Composition, and Biological Utilization*
MMS 2008-050 MMS 2008-051	*Labor Needs Survey* *Volume I: Technical Report* *Volume II: Survey Instruments*
MMS 2008-052	*Benefits and Burdens of OCS Activities on States, Labor Market Areas, Coastal Counties, and Selected Communities*
MMS 2008-058	*Cumulative Increment Analysis for the Breton National Wilderness Area*
Published in 2007	
Study Number	Title
MMS 2007-015	*Archaeological and Biological Analysis of World War II Shipwrecks in the Gulf of Mexico; Artificial Reef Effect in Deepwater*
MMS 2007-019	*Mixtures of Metals and Polynuclear Aromatic Hydrocarbons May Elicit Complex, Nonadditive Toxicological Interactions*
MMS 2007-022	*Full-Water Column Current Observations in the Central Gulf of Mexico: Final Report*
MMS 2007-030	*Incorporation of Gulf of Mexico Benthic Survey Data into the Ocean Biogeographic Information System*
MMS 2007-031	*Idle Iron in the Gulf of Mexico*
MMS 2007-033	*Cooperative Research to Study Dive Patterns of Sperm Whales in the Atlantic Ocean*
MMS 2007-034	*Competition and Performance in Oil and Gas Lease Sales and Development in the U.S. Gulf of Mexico OCS Region, 1983-1999*
MMS 2007-035	*Seafloor Characteristics and Distribution Patterns of* Lophelia pertusa *and Other Sessile Megafauna at Two Upper-Slope Sites in the Northeastern Gulf of Mexico*
MMS 2007-044	*Characterization of Northern Gulf of Mexico Deepwater Hard-Bottom Communities with Emphasis on* Lophelia *Coral*
MMS 2007-056	*Full-Water Column Currents Near the Sigsbee Escarpment (91-92º W. Longitude) and Relationships with the Loop Current and Associated Warm- and Cold-Core Eddies*
MMS 2007-061	Study of Barite Solubility and the Release of Trace Components to the Marine Environment
MMS 2007-067	*Year 2005 Gulfwide Emission Inventory Study*

MMS 2007-068	*User's Guide for the 2008 Gulfwide Offshore Activities Data System (GOADS-2008)*
Published in 2006	
Study Number	Title
MMS 2006-005	*Fidelity of Red Snapper to Petroleum Platforms and Artificial Reefs in the Northern Gulf of Mexico*
MMS 2006-011	*Sustainable Community in Oil and Gas Country: Final Report*
MMS 2006-028	*Degradation of Synthetic-Based Drilling Mud Base Fluids by Gulf of Mexico Sediments, Final Report*
MMS 2006-030	*Accounting for Socioeconomic Change from Offshore Oil and Gas: Cumulative Effects on Louisiana's Coastal Parishes, 1969-2000*
MMS 2006-034	*Sperm Whale Seismic Study in the Gulf of Mexico, Summary Report: 2002-2004*
MMS 2006-035	*Long-Term Monitoring at the East and West Flower Garden Banks National Marine Sanctuary, 2002-2003*
MMS 2006-036	*Study to Conduct National Register of Historic Places Evaluations of Submerged Sites on the Gulf of Mexico Outer Continental Shelf*
MMS 2006-037	*Effect of Depth, Location, and Habitat Type, on Relative Abundance and Species Composition of Fishes Associated with Petroleum Platforms and Sonnier Bank in the Northern Gulf of Mexico*
  MMS 2006-044 MMS 2006-045 MMS 2006-046	*Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico;* *Volume I: Executive Summary* *Volume II: Technical Report* *Volume III: Appendices*
MMS 2006-063	*Economic Effects of Petroleum Prices and Production in the Gulf of Mexico OCS on the U.S. Gulf Coast Economy*
MMS 2006-064	*Capital Investment Decisionmaking and Trends in Petroleum Resource Development in the U.S. Gulf of Mexico*
MMS 2006-067	*Sperm Whale Seismic Study in the Gulf of Mexico, Annual Report: Years 3 and 4*
MMS 2006-071	*Annotated Bibliography of the Potential Environmental Impacts of Chlorination and Disinfection Byproducts Relevant to Offshore Liquefied Natural Gas Port Facilities*
MMS 2006-072	*Mica Shipwreck Project Report: Deepwater Archaeological Investigation of a 19th Century Shipwreck in the Gulf of Mexico*
 MMS 2006-073 MMS 2006-074	*Exploratory Study of Deepwater Currents in the Gulf of Mexico* *Volume I: Executive Summary* *Volume II: Technical Report*

APPENDIX F

AGENCY-FUNDED HURRICANE RESEARCH AND STUDIES

APPENDIX F. AGENCY-FUNDED HURRICANE RESEARCH AND STUDIES

Project/Study Number	Title
Hurricanes Katrina and Rita	
BOEMRE 2011-003 (in press)	*Impacts of Recent Hurricane Activity on Historic Shipwrecks in the Gulf of Mexico Outer Continental Shelf*
MMS 2009-060	*Modeling Waves and Currents Produced by Hurricanes Katrina, Rita, and Wilma*
MMS 2009-032	*Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity*
MMS 2008-019	*Post-Hurricane Assessment at the East Flower Garden Bank Long-Term Monitoring Site: November 2005*
GM-07-x12	Assessing Impact of OCS Activities on Public Infrastructure, Service, and Population in Coastal Communities Following Hurricanes Rita and Katrina
GM-92-42-124	Post-Hurricane Assessment of OCS-Related Infrastructure and Communities in the Gulf of Mexico Region
GM-92-42-125	Spatial Restructuring and Fiscal Impacts in the Wake of Disaster: The Case of the Oil and Gas Industry Following Hurricanes Katrina and Rita
GM-92-42-137	Socioeconomic Responses to Coastal Landloss and Hurricanes: Measuring Resilience Among OCS-Related Coastal Communities in Louisiana
GM-92-42-131	Gulf Coast Subsidence and Wetland Loss: A Synthesis of Recent Research
Project No. 578	Assessment of Fixed Offshore Platform Performance in Hurricanes Katrina and Rita
Project No. 580	Hindcast Data on Winds, Waves and Currents in Northern Gulf of Mexico in Hurricanes Katrina and Rita
Project No. 581	Pipeline Damage Assessments from Hurricanes Katrina and Rita
Project No. 591 (completed December 5, 2007)	Evaluate Accuracy of Polyester Subrope Damage Detection Performed by Remotely-Operated Vehicles (ROV's) Following Hurricanes and Other Events
Project No. 593	Evaluate and Assess the Performance of Jackup Rigs That Were Subject to Hurricanes Katrina or Rita
Project No. 599	JIP to Quantify Risks in Deepwater Production Facilities and Flowlines in the GOM
Project No. 603	Stability of Tension-Leg Platforms (TLP's) with Damaged Tendons

Project No. 604	Evaluation of Fatigue Life Models and Assessment Practice for Tension-Leg Platforms (Phase 1: Tendon System Fatigue)
Project No. 605	Cooperative Research on Extreme Seas and Their Impact to Floating Structures
Project No. 609	Reliability vs. Consequence of Failure for API RP 2A Platforms Using RP2MET
Hurricane Ivan	
GM-05-x12	Ocean Currents under Hurricane Ivan on the Mississippi/Alabama Shelf
Project No. 548	Examination and Review of Mobile Offshore Drilling Unit (MODU) Loss of Station-keeping Ability during Hurricane Ivan and Assessment of Current Mooring Standards and Criteria to Prevent Similar Failures
Project No. 549	Assessment of Fixed Offshore Platforms in Hurricane Ivan, Andrew
Project No. 550	A Pilot Study for Regionally-Consistent Hazard Susceptibility Mapping of Submarine Mudslides, Offshore Gulf of Mexico
Project No. 551	Assessment of Drilling and Workover Rig Storm Sea Fastenings on Offshore Floating Platforms during Hurricane Ivan
Project No. 552	Mudslides during Hurricane Ivan and an Assessment of the Potential for Future Mudslides in the GOM
Project No. 553	Pipeline Damage Assessment from Hurricane Ivan
Project No. 559	Offshore Hurricane Readiness and Recovery Conference
Hurricane Lili	
Project No. 466	Validation and Calibration of API RP2A Using Hurricane Lili to Update the Hurricane Andrew JIP Results that Provided the Basis for API Section 17
Project No. 467	Hindcast Study of Winds, Waves, and Currents in Northern GOM in Hurricane Lili (2002)
Project No. 469	Post-Mortem Failure Assessment of Drilling Rigs during Hurricane Lili
Project No. 471	Assessment of Performance of Deepwater Floating Production Facilities
Project No. 503	Evaluate and Compare Hurricane-Induced Damage to Offshore Pipelines for Hurricane Lili—Rev. A
Hurricane Andrew	
Project No. 193	Study and Hindcast of Wind and Wave Fields for Hurricane Andrew
Project No. 199	Hurricane Andrew Calibration Study
Project No. 201	Evaluation of Hurricane Pipeline Damage

Project No. 203	Performance of Safety and Pollution Control Devices in the Aftermath of Hurricane Andrew (Part of the Hurricane Andrew OCS Damage Assessment Program)
Project No. 204	Post-Mortem Platform Failure Evaluation Study
Project No. 206	Shallow-Water Wave and Current Field Study
Project No. 207	API/Hurricane Foundation Study
Project No. 209	Development of Acceptance Criteria for Caisson Structures Damaged during Hurricane Andrew
Project No. 210	Hurricane Andrew Effects on Offshore Platforms
Project No. 224	Dynamic Nonlinear Loading Effects on Offshore Platforms
Project No. 229	Hurricane Andrew Effects on Offshore Platforms (Phase II – JIP)

KEYWORD INDEX

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